Presented to the Interdisciplinary Studies Program:

UNIVERSITY OF OREGON
APPLIED INFORMATION MANAGEMENT

Applied Information Management
and the Graduate School of the
University of Oregon
in partial fulfillment of the
requirement for the degree of
Master of Science

Learning by Design: Cognitive and Emotional Factors Influencing Informal Learning Experiences in Interactive Environments

CAPSTONE REPORT

Nicole Leaper
Senior Communication Designer
Bullseye Gallery/Bullseye Glass Co.

University of Oregon
Applied Information
Management
Program

February 2011

Continuing Education
1277 University of Oregon
Eugene, OR 97403-1277
(800) 824-2714

Approved by

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Dr. Linda F. Ettinger
Senior Academic Director, AIM Program

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Nicole Leaper

Bullseye Gallery/Bullseye Glass Co.

Abstract

This study synthesizes current literature in educational and design psychology, information design, human-computer interaction, and museum studies to identify cognitive and emotional factors that influence learning. The purpose is to produce a set of cognitive and emotional factors that museum educators, exhibit designers, information designers, and interaction designers should consider when designing informal learning experiences in interactive environments. Nine identified factor groups include affect, cognition, context, engagement, experiential learning, interactivity, narrative, self concepts, and usability.

Keywords: affect, cognition, design psychology, emotional design, engagement, experience design, experiential learning, information design, interaction design, museum studies.

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Introduction

Problem Area

Human interactions with information. Human consciousness can be defined as "an organizing principle of information processing by individuals acting in environments" (Carlson, 1997a, p. 126). The great influx of information with which humans interact on a daily basis requires human-centered approaches to information experiences (Wurman, Leifer, Sume, & Whitehouse, 2001). In order to engage with information in a meaningful way, formal and informal learning experiences must be designed using experiential, human-centered approaches (Dewey, 1938). This approach is examined in an area of inquiry known as experience design, which can be described as creating interactive situations for humans (Forlizzi & Ford, 2000, p. 420), and is also a broad term for design concerned with the "holistic user experience" with aspects that include information architecture, usability engineering, visual design, and interaction design (Morville & Rosenfeld, 2006, p. 10). Experience design exists as part of human-centered design, which can be defined as recognizing human needs in order to "[enhance] effectiveness and efficiency" ("UsabilityNet: Methods: ISO 13407," n.d.) of an information experience. An important aspect of human-centered experience design is usability design, which can be defined as the practice of designing for ease of use, a field rooted in "cognitive sciences—a combination of psychology, computer science, human factors, and engineering" (Norman, 2002, p. 38).

Human interactions with information are viewed as both cognitive and emotional experiences; for example, learning and recall are affected by emotions that are present when cognition occurs (Carlson, 1997a, p. 123), and "the arousal accompanying emotion has an informational aspect, constituting part of the information manifold in which experienced cognition occurs" (Carlson, 1997a, p. 113). Kolb et al. define ideal learning experiences as a

"spiral" of cognitive responses including "experiencing, reflecting, thinking, and acting" (Kolb, Boyatzis, & Mainemelis, 2001, p. 240). Forlizzi and Ford (2000) define cognitive experiences as interactions which "require us to think about what we are doing…[and] require attention, cognitive effort, or problem-solving skills [sic]" (p. 421).

Dewey (1938) proposed that "all human experience is ultimately social...it involves contact and communication" (p. 38). Human interactions with information are also social experiences; for example, humans consistently apply social rules (politeness, perceptions of gender) when interacting with computers (Lamb & Kling, 2003; Nass, Steuer, & Tauber, 1994). Lamb and Kling (2003) note that humans make choices about information communication technologies based on social aspects of their environment. Information experiences, like product experiences, exist in "a context of use, shaped by social, cultural and organizational behavior patterns" (Forlizzi & Ford, 2000, p. 420).

Experiential and informal learning. Experiential learning theory is an educational model based on the idea that humans create meaning from experience. Dewey's (1938) foundational work in this area suggests "there is an intimate and necessary relation between the processes of actual experience and education" (p. 20). Kolb created a formal Experiential Learning Theory (ELT) in 1984 based on the work of John Dewey, Kurt Lewin, and Jean Piaget (Kolb et al., 2001, p. 228). Both cognition and affect (emotion) influence ways humans process information (Norman, 2002, p. 38) and cognitive styles influence learning experiences (Kolb et al., 2001), including informal learning experiences. Informal learning can be defined as short-term, voluntary learning which occurs outside of a formal curriculum (such as classes, self-directed research, museums and galleries, etc.); this type of learning can be self-directed, incidental, or socialized (Schugurensky, 2000).

Interactive learning environments. Researchers exploring contemporary learning in museums suggest that informal learning is enhanced when humans participate in interactive experiences (Allen, 2004; Birchfield, Mechtley, Hatton, & Thornburg, 2008). Birchfield et al. (2008) note, "contemporary research in the learning sciences emphasizes the importance of active learning, collaborative learning, and constructionist learning" (2008, p. 965). Allen (2004) defines active prolonged engagement as creating both "minds-on" and "hands-on" experiences, especially those that combine "access to phenomena with opportunities for deeper cognitive experiences" (p. S25). Allen's (2004) work suggests "exhibits may have an optimal degree of interactivity, and that formative evaluation is essential for ensuring that the interactive features work together harmoniously" (Ibid).

Informal and experiential learning, in an interactive environment such as a museum, has the potential to be mutually beneficial for both the participant (the learner) and the experience provider (the museum); for example, participants often develop an affinity for or emotional engagement with the provider of a positive experience (Damazio, Dal Bianco, Lima, & Menezes, 2009). Van Moer et al. (2008) note, "information-based exhibits often create reactions without personal engagement and develop experiences not meaningful enough to capture visitors' attention and open up to further growth" (p. 44). Continued exploration results when human impulses and desires are recognized as motivating factors in an educational experience (Dewey, 1938).

Purpose

The purpose of the study is to produce a set of factors, identified in selected literature, that museum educators, exhibit designers, information designers, and interaction designers should consider when designing informal learning experiences. Focus of the study is on cognitive and emotional factors (Carlson, 1997b; Damazio et al., 2009) inherent in information environments and not ergonomic or physical accessibility factors. In order to identify factors, the study focuses on concepts rather than product studies or licensed approaches. The study specifically addresses informal learning experiences for adults, rather than child education or higher learning.

Literature is collected in the areas of: (a) cognitive experiences associated with information design (Carlson, 1997b; Wurman et al., 2001); (b) social and emotional aspects of information experiences (Damazio et al., 2009; Jordan, 2010; Lamb & Kling, 2003; Nass et al., 1994); and (c) experiential learning theory as it applies to museum settings (Hein, 2004; Hennes, 2002). The study focuses on emotional and cognitive factors in order to describe what is important for humans interacting with information during informal learning experiences. Factors are identified through conceptual analysis (Busch et al., 2005).

Although the research centers on experiential learning applied in the museum context, this researcher assumes that factors influential in designing for learning in physical museum spaces could be beneficial to designers creating other informal learning experiences, both digital and physical. The goal of this study is to examine ways humans connect with and process information in interactive environments. The intent is to help guide the design of human-centered interactions with information in order to facilitate informal learning.

For the purpose of this study, an experience is defined as "a transaction taking place between an individual and what, at the time, constitutes his environment" (Dewey, 1938, p. 43), and an environment is defined as "whatever conditions interact with personal needs, desires, purposes, and capacities to create the experience" (Ibid, p. 44). An interactive environment is defined as one that accepts and responds to input from humans ("Interactivity - Wikipedia, the free encyclopedia," n.d.). Human-centered learning experiences are defined as those which incorporate a usability design process in order to identify and respond to human needs ("UsabilityNet: Methods: ISO 13407," n.d.), especially those experiences which enhance effectiveness of learning and encourage ongoing exploration (Hennes, 2002). Usability design refers to the practice of designing for ease of use, a field rooted in the "cognitive sciences—a combination of psychology, computer science, human factors, and engineering" (Norman, 2002, p. 38). Informal learning is defined as short-term, voluntary learning that occurs outside of a formal curriculum; it can be self-directed, incidental, or tacit (socialized) (Schugurensky, 2000).

Significance

Academic significance. According to Creswell (2009), literature reviews are inherently significant if they "add to the pool of research knowledge" (p. 24). This study contributes knowledge by synthesizing current research from multiple disciplines (educational and design psychology, information design, human-computer interaction, and museum studies) and identifying areas of overlap and omission between fields.

Practical significance. Human interactions with information are growing and becoming more complex (Wurman et al., 2001). Information should be designed from a human-centered perspective (Norman, 2002, p. 40) in order to provide learning experiences that encourage ongoing exploration (Hein, 2004). Studies show human creativity and learning is enhanced

during positive emotional states (Norman, 2004, p. 19). Although the amount of research in the area of design and emotion has increased in the last decade, design theory and practice have not fully capitalized on the advances from the last 25 years regarding the biology and neurology of emotion (Love, 2009). In order to create these experiences, designers must have access to the findings of current scholarly research in a form that allows them to apply current knowledge to their practice (Kolko, 2010, p. 80). By identifying influential cognitive and emotional factors emergent in current research, this study brings academic knowledge to practitioners in order to encourage the creation of human-centered learning experiences with information.

Audience/Outcome

This study is developed for creators of informal, interactive learning experiences like museum educators, exhibit designers, information designers, and interaction designers. In a museum setting, each of these professionals has a mission to offer information in a way that engages participants and encourages ongoing exploration (Dewey, 1938; Hein, 2004; Hennes, 2002). Current cognitive research suggests a need to design for mental models based on what humans desire to accomplish (Young, 2008, p. 8), and for individualized ways humans learn (Kolb et al., 2001). The assumption underlying this study is that awareness of cognitive and emotional factors identified in current research could guide creators of informal learning experiences in interactive environments, in order to offer participants meaningful information experiences, with the intention to enrich learning and encourage further participant exploration.

The outcome of this study presents a set of factors that museum educators, exhibit designers, information designers, and interaction designers should consider when designing interactive learning environments. The study identifies relevant factors, discusses them individually, and provides an overview of how each fits into current academic research in a

visual study results matrix (Appendix A), showing areas of overlap and omission between fields. Because the study is intended to serve practitioners, a high-level overview of the study is also presented in the form of a white paper (Appendix B) that can be used to guide the creation of human-centered interactive learning environments.

Research Delimitations

Topic. The study identifies cognitive and emotional factors influencing informal learning experiences in interactive environments, as present in current scholarly literature, in order to provide an overview of an interdisciplinary topic. The intent is to synthesize current research (Cooper, 1998, p. 2) from four distinct areas (educational and design psychology, information design, human-computer interaction, and museum studies) and present it in a form applicable to both scholars and design practitioners in these areas. Individually, these subject areas explain aspects of a user's learning experience, but collectively current research provides a more complex and interdisciplinary overview of that experience.

The study centers on experience design and experiential learning theory, operating on the assumption that individualized, human-centered design will provide optimal outcomes for participants engaging in informal learning experiences. Experiential learning theory recognizes that the individual is an integral part of learning "situations" comprised of interactions and continuity (Dewey, 1938) and places a particular emphasis on individual needs and interactions (Kolb et al., 2001). Although there are numerous historical design theories and approaches that may provide positive human outcomes, this researcher believes a contemporary, human-aware design approach should recognize ways differing design theories serve the user, and apply sophisticated solutions balancing human needs with other concerns.

Focus. Focus of the study is on cognitive (Carlson, 1997b) and emotional (Damazio et al., 2009) factors which influence informal learning in interactive information environments, such as museums (Hennes, 2002) and not ergonomic or physical accessibility factors. Human factors research includes many human-related concerns in the designed world ("Human Factors and Ergonomics Society: Educational resources," n.d.), but this study focuses on information and learning psychology rather than physical engineering aspects of interactive learning environments. Although cognitive and emotional factors may influence physical design, this study identifies influential factors rather than suggesting physical applications. The study focuses on adult factors rather than those specific to children or early education. In order to extract factors, references addressing concepts and theories are preferred to those describing product studies or licensed approaches.

Audience. The intended audience for the study is creators of informal, interactive learning experiences like museum educators, exhibit designers, information designers, and interaction designers, in order to connect practitioners with current academic knowledge (Kolko, 2010). The study may also be of interest to a wider field including academic educators, design researchers, and industrial designers since cognitive and emotional factors affecting learning could provide insight for creators of a variety of human-centered designed experiences, both digital and physical.

Time frame. The literature search focuses on literature published during the five years, spanning January 1, 2005 to December 31, 2010, in order to create a synthesis of current knowledge in the field (Cooper, 1998, p. 2). Older, foundational publications referenced by current sources are also included to provide context.

Type of sources. Literature is limited to scholarly (including peer reviewed) literature addressing the cognitive and emotional aspects of information design practices applicable to informal, interactive learning environments. Peer-reviewed journal articles and references whose content addresses multiple keywords are preferred, and peer-reviewed association publications like ACM's *interactions* magazine (Jordan, 2010) are also included. Recent non-academic publications by respected scholars, such as Donald Norman's *Emotional Design* (2004), are included, along with respected publishers such as O'Reilly (Morville & Rosenfeld, 2006) and Rosenfeld (Young, 2008), to provide definitions and context.

Type of research design. The research study is approached from a constructivist philosophical worldview (Creswell, 2009, p. 8). The researcher has a communication design and fine art background, so a qualitative research design is desirable and literature employing qualitative strategies of inquiry, including those describing experiences (phenomenology) and explaining or seeking to understand (ethnography) are emphasized in the study (Creswell, 2009, p. 13). The study is designed as research synthesis (Cooper, 1998, p. 3) and presented as an integrative literature review (Ibid, p. 2).

Data Analysis Plan Preview

Data collection process. Creswell (2009) identifies qualitative research as an iterative process of reflection, questioning, and writing; he notes, "qualitative data analysis is conducted concurrently with gathering data, making interpretations, and writing reports" (p. 184). An initial group of references addressing the research question and sub-questions are collected, but the analysis and interpretation portion of the research process informs these questions and they evolve during the research process, leading to further data collection.

Data coding and analysis procedure. High-quality, relevant references are coded by topic using content analysis procedures (Busha & Harter, 1980). The goal is to "quantify and analyze the presence, meanings and relationships of…words and concepts [within a text], then make inferences about the messages within the texts, the writer(s), the audience, and even the culture and time of which these are a part" (Busch et al., 2005). A coding process is implemented that includes eight stages (Busch et al., 2005):

- Level of analysis
- Number of concepts
- Existence of a concept
- Level of generalization
- Translation rules
- Irrelevant information
- Code the texts
- Analyze results

Writing Plan Preview

Review of literature. An overview of current literature, as revealed by conceptual analysis of relevant factors, is presented in a visual overview as a study results matrix (see Appendix A). Factors subject areas and tags are recorded in order to reveal meaning through emerging patterns, areas of overlap, and areas of omission. Influential cognitive and emotional factors identified in the matrix are clustered into factor groups and discussed with regard to their relationships to humans, design, and other factor groups. Study results and analysis are discussed collectively to provide a research results overview, in order to build bridges between subject areas (Cooper, 1998, p. 3).

Design stakeholder and practitioner report. A study synopsis, targeted to a business audience comprised of design stakeholders including practitioners, is presented as a separate report in the form of a white paper (Appendix B). The white paper presents study information at a high level suitable for business use and executive review. The white paper includes an

executive summary, identified factors clustered into factor groups, definitions, overviews of subject area and research methods, and a bibliography.

Definitions

The definitions presented in this section of the study are identified in the selected literature. The definitions offer a specific meaning within the context of the study, and are provided in order to create a shared understanding of terms within a specific conceptual context (Creswell, 2009, p. 39).

Active learning. Learning in a self-guided and problem-solving context, as opposed to learning through passive "tutorial-like, prompted interaction" (Van Nimwegen, Van Oostendorp, Burgos, & Koper, 2006, p. 786). Research suggests it's possible that "the more difficult condition perhaps instigates a deeper level of cognitive processing which eventually results in more effective learning" (Ibid)(2006, p. 786).

Active prolonged engagement. Defined by Allen (2004) as creating both "minds-on" and "hands-on" experiences, especially those that combine "access to phenomena with opportunities for deeper cognitive experiences" (p. S25).

Affect. A "neutral" term describing "the concepts of affect, emotion, feelings, mood, motivation, and qualia" (Norman, 2002, p. 38). The "affective system is judgmental, assigning positive and negative valence to the environment rapidly and efficiently"; affect and cognition work together to help humans process information (Ibid).

Cognition. Defined by Norman (2002) as a neurological response that "interprets and makes sense of the world"; affect and cognition work together to help humans process information (p. 38).

Cognitive experience. The stream of incoming information perceived by humans during consciousness, according to Richard Carlson's (1997b) theory of experienced cognition. Also

defined as interactions which "require us to think about what we are doing [and] require attention, cognitive effort, or problem-solving skills [sic]" (Forlizzi & Ford, 2000, p. 421).

Communication design. A holistic design approach which recognizes that designed information inherently exists inside of an experience; designers don't create artifacts but rather events (Frascara, 2004, p. 13).

Contemporary learning theories. Theories modeled on "contemporary research in the learning sciences [emphasizing] the importance of active learning, collaborative learning, and constructionist learning" (Birchfield et al., 2008, p. 965).

Context. For the purposes of the study, defined as influences surrounding and shaping experiences; Forlizzi and Ford (2000) note "user-product interactions take place in a context of use, shaped by social, cultural, and organizational behavior patterns" (p. 420).

Engagement. Can be described as prolonged interaction created by elements of "Focused Attention, Perceived Usability, Aesthetics, Endurability, Novelty, and Felt Involvement" (O'Brien & Toms, 2010, p. 62). Can include a flow state, which can be defined as being "fully involved with mind and body in an intrinsically motivated activity" (Allen, 2004, p. S23).

Experience. "A stream of valuable and not so valuable moments with a definite beginning…and ending" (Hassenzahl & Ullrich, 2007, p. 429). Defined by Dewey (1938) as "a transaction taking place between an individual and what, at the time, constitutes his environment" (p. 43); the environment is "whatever conditions interaction with personal needs, desires, purposes and capacities to create the experience" (p. 44).

Experience design. Creating interactive situations for humans (Forlizzi & Ford, 2000, p. 420); a broad term for design concerned with the "holistic user experience," with aspects that

include information architecture, usability engineering, visual design, and interaction design (Morville & Rosenfeld, 2006, p. 10).

Experiential learning theory. An educational model based on the idea that humans create meaning from experience. Kolb created a formal Experiential Learning Theory (ELT) in 1984 based on the work of John Dewey, Kurt Lewin, and Jean Piaget (Kolb et al., 2001, p. 228).

Educational psychology. Applying psychological understanding to improve educational experiences; Entwistle et al. (2001) note that "educational research from a psychological perspective is generally directed towards a deeper understanding of teaching and learning processes in everyday contexts, with the ultimate intention of improving the quality and effectiveness of education" (pp. 103-104).

Human-centered design. "A multidisciplinary activity, which incorporates human factors and ergonomics knowledge and techniques with the objective of enhancing effectiveness and efficiency, improving human working conditions, and counteracting possible adverse effects of use on human health, safety and performance" ("UsabilityNet: Methods: ISO 13407," n.d.).

Human factors. The broad field of study concerning the cognitive, social and physical aspects of human systems and services, including ergonomics ("Human Factors and Ergonomics Society: Educational resources," n.d.).

Informal learning. Short-term, voluntary learning which occurs outside of a formal curriculum; it can be self-directed, incidental, or socialized (Schugurensky, 2000).

Information architecture. "The structure and design of shared information environments," such as information products and experiences, that support the human-centered attributes of usability and findability (Morville & Rosenfeld, 2006, p. 4).

Interaction design. Creating interfaces for the "behavior of tasks and processes" humans encounter in an information system (Morville & Rosenfeld, 2006, p. 10).

Interactive environment. For the purposes of the study, defined as an environment that accepts and responds to input from humans ("Interactivity - Wikipedia, the free encyclopedia," n.d.).

Interactivity. "A feedback loop of action-reaction-interaction [which] involves collaboration or exchange" (Polaine, 2005, p. 151).

Narrative. In terms of exhibition design, a structure which "allows the audience to make sense of the objects on display, in relation to one another and their surrounding contexts" (Lake-Hammond & Waite, 2010, p. 91).

Shareability. A "design principle that refers to how a system, inter-face, or device engages a group of collocated, co-present users in shared inter-actions around the same content (or the same object) [sic]" (Hornecker, Marshall, & Rogers, 2007, p. 328).

Self concepts. For the purposes of the study, defined as influences on experience concerned with identity and self; designed experiences are inherently tied to the self, since "identity, like interest, develops through interactions…both interest and identity develop in relation to available experiences and to how learners perceive, understand, and represent these experiences" (Renninger, 2009, p. 106).

Social actor. "An organizational entity whose interactions are simultaneously enabled and constrained by the socio-technical affiliations and environments of the firm, its members, and its industry" (Lamb & Kling, 2003, p. 218).

Usability design. The practice of designing for ease of use, a field rooted in "cognitive sciences—a combination of psychology, computer science, human factors, and engineering"

(Norman, 2002, p. 38). *Usability* derives from *userfriendly*, but "no precise definition of usability exists" (Alonso-Ríos, Vázquez-García, Mosqueira-Rey, & Moret-Bonillo, 2010, p. 53); many researchers rely on international standards (ISO) definitions (Ibid, p. 54)(Alonso-Ríos et al., 2010, p. 54).

User-centered design. An approach that promotes "the creation of objects that, by virtue of their physical forms and location invite certain kinds of use and not others," including the notion of "affordances" or interactions where intended use is natural and apparent (Allen, 2004, p. S21).

White paper. An "authoritative" and "informative" publication which "argue[s] a specific position or propose[s] a solution to a problem" and often addresses an audience outside the originating organization (Sakamuro & Stolley, 2010).

Research Parameters

The framing of this topic requires development of an intersection between the fields of information design (Morville & Rosenfeld, 2006; Wurman et al., 2001), human-computer interaction (Lamb & Kling, 2003; Nass et al., 1994), design psychology (Norman, 2004) educational psychology (Dewey, 1938; Kolb et al., 2001), and museum studies (Hein, 2004; Hennes, 2002). The study is designed as a literature review, which enables the researcher to link pertinent information from these areas into a cohesive body of knowledge in order to "build bridges to related topic areas" (Cooper, 1998, p. 3).

Research Questions

Primary research question. According to selected literature, what cognitive and emotional factors should museum educators, exhibit designers, information designers, and interaction designers consider when designing informal learning experiences in interactive learning environments?

Secondary research questions.

- How do participants interact with information in a self-directed interactive environment like a museum setting?
- What outcomes define a positive informal learning experience in a self-directed interactive environment like a museum setting?
- How do selected current theories describe cognitive responses during informal learning experiences, especially in interactive environments?
- How do selected current theories describe emotional responses during informal learning experiences, especially in interactive environments?

Search Strategy

Search process. The search process follows Creswell's (2009) method to capture, evaluate, and summarize relevant data (p. 29). Creswell's (2009) approach to literature review includes five stages:

1. Identify key words to be used as search terms.
2. Locate a body of references and skim each to evaluate relevance to the topic.
3. Design a literature map in order to provide an understanding of where the literature review fits into the existing literature, and show a "visual picture of existing research about a topic" (Ibid, p. 34).
4. Write summaries of found material.
5. Assemble literature review organized by theme or concept.

Search terms. Search terms are derived from the text in academic literature, such as journal articles, including *Journal of the American Society for Information Science and Technology* (O'Brien & Toms, 2008) and conference papers, including the International Association of Societies of Design Research (IASDR)'s 2009 conference on Rigor and Design (Love, 2009), peer-reviewed publications, such as the Association for Computing Machinery (ACM)'s *interactions* magazine (Jordan, 2010), foundational books like John Dewey's *Experience and Education* (1938), and international standards, such as Usability Net's public listing of ISO definitions ("UsabilityNet: Methods: ISO 13407," n.d.). Search terms include:

- human-centered design
- information design
- information experience
- experience design
- user experience design
- user engagement
- interaction design
- interactive learning

- emotional learning
- cognitive learning
- experiential learning
- museum education
- museum participants
- museum mission
- museum educators

Search results. The list of search terms and term combinations were tested in initial organic searches using Google Scholar linked to UO FindText and WorldCat. The quantity of available relevant materials is high for individual search terms (a search for *human-centered design* in Google Scholar yields 2100 results), but searches can be narrowed by combining terms (searching for *human-centered design* and *user engagement* together yields 31 results). Many results focused around studies for specific, branded design products; the most applicable results from a theoretical perspective are recent scholarly publications building on foundational work. Found literature that addresses multiple search terms, ties foundational theories to new research and academic thinking, and is applicable across disciplines is considered the most relevant to the study. Key terms determined from initial searches and search limitations (peer-reviewed references published within the last five years) were used for focused searches in topic-specific databases. Table 1 shows an overview of relevant search results.

Table 1

Search results

Source	Search Type	Search Queries	Relevant Results
Association for Computing Machinery (ACM) Digital Library	Systematic	69	14
Anthrosource	Systematic	15	2
Design and Applied Arts Index (DAAI)	Systematic	19	5
Google Scholar linked to UO FindText and WorldCat	Organic	Multiple	31
Researcher's library	Not applicable	Not applicable	3
Psychology & Behavioral Sciences Collection	Systematic	58	4
		Total Relevant Sources	57

Note. Systematic searches utilize all key terms, either individually or organized into specific, grouped search queries. Organic searches use some of the key terms, grouped in evolving ways, with each search result influencing the next search. Initial organic searches helped to develop the complete list of key terms used for systematic searches of specific databases.

Search result areas. Initial found references prompt additional organic searches in the following areas:

- Information design, experience design, and learning
- Social and emotional aspects of information experiences
- Cognition and emotion as aspects of informal learning experiences
- Examples of contemporary experience design in museum settings
- Experiential learning theory as it applies to museum settings

Search results in these areas prompt refinement of key terms applied to systematic searches in relevant databases, and the creation of a taxonomy (see Table 2). References are

tagged with terms from the taxonomy and literature maps are created to show search results by date (Figure 1) and subject area (Figure 2).

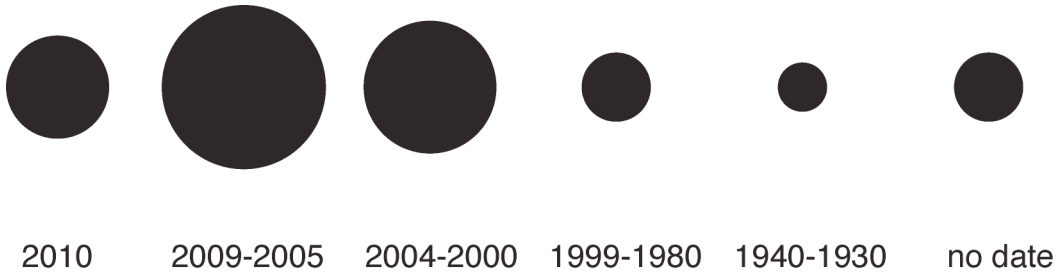

Figure 1. Visual overview of search results (literature map) by date.

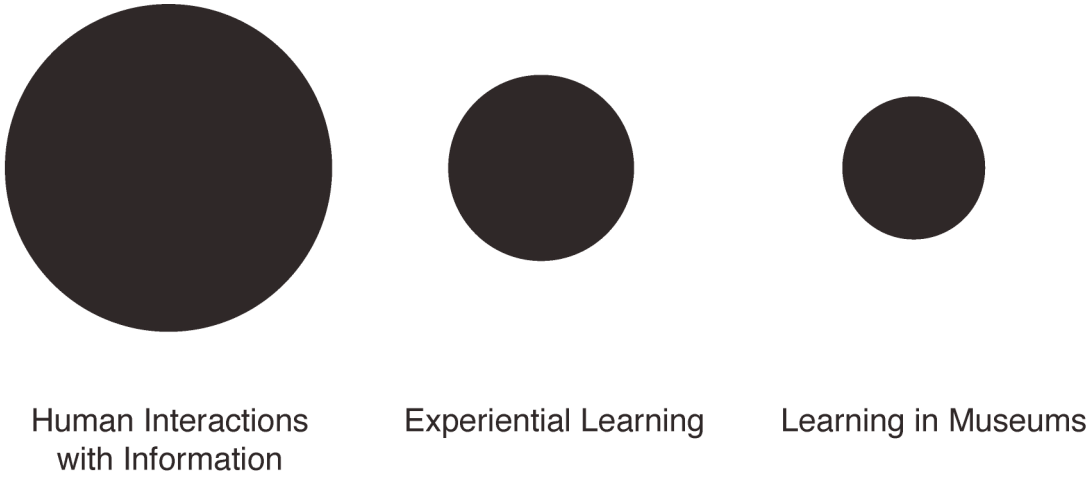

Figure 2. Visual overview of search results (literature map) by subject area.

Table 2

Taxonomy of key terms

HUMAN INTERACTIONS WITH INFORMATION
human-centered design
- (43) **experience design** (use for: user experience design, UX)
  - usability design (use for: user-centered design, usability, user testing, usability engineering)
    - design research (use for: user research)
      - ethnography
      - user testing
      - usability engineering
  - information design
    - information experience
    - information architecture
    - information visualization
  - visual design (use for: visual communication)
  - interaction design
  - human-computer interaction (use for: HCI, interactive computer systems, human interface design)
  - communication design

- (34) **design psychology**
  - identity
  - engagement (use for: user engagement)
  - aesthetic experience (use for: aesthetics)
  - cognition
  - emotion
  - social interaction
  - inquiry

EXPERIENTIAL LEARNING
educational psychology
- (17) **experiential learning**
  - cognitive learning
  - emotional learning
  - interactive learning
  - informal learning
  - self-directed learning
  - social learning (use for: co-creation)

LEARNING IN MUSEUMS
museum studies
- (10) **museum education**
  - museum mission
  - museum educators
  - museum participants
  - exhibition design

Note. The taxonomy is created using key terms (derived from the literature and developed through initial, organic searches) combined with existing reference tags created by the reference author or publisher. Duplicates are removed, and terms are re-organized into subject areas identified in the Problem Area section of the Introduction (human interactions with information, experiential learning, and learning in museums). Taxonomy terms highlighted in **bold** (experience design, design psychology, experiential learning, and museum education) are used to tag each reference during the primary coding phase, in order to show subject areas, subject area overlap, and identify highly relevant references for the secondary coding phase. Quantities in (parenthesis) show number of relevant sources related to each term.

Literature resources. The parameters of the search encompass scholarly (including peer reviewed) literature addressing the cognitive and emotional aspects of human-centered information design practices applicable to informal learning experiences in interactive environments. Because one of the goals of a literature review is to mitigate information overload by synthesizing a large amount of current data into a format that can be readily absorbed (Cooper, 1998, p. 2), the search is focused on very recent literature published from January 1, 2005 to December 31, 2010, with the addition of specific older foundational, often-referenced material such as Csikszentmihalyi's work on experience flow (Csikszentmihalyi & LeFevre, 1989) and Dewey's theories on experiential learning (1938).

Additional literature resources. Because the topic addresses emerging cross-disciplinary information, additional literature resources include recent publications by respected practitioners such as Rosenfeld publications (Young, 2008) and association publications like the ACM's *interactions* magazine (Jordan, 2010).

Search engines. The primary search tool used is the Google Scholar search engine, linked to the University of Oregon's FindText and WorldCat.

Databases. Academic databases searched include the Association for Computing Machinery (ACM) Digital Library, Psychology & Behavioral Sciences Collection, Anthrosource, and the Design and Applied Arts Index (DAAI). Scholarly literature sources include academic books, peer-reviewed journal articles, conference papers, and international standards. References

from relevant references are examined to discover chains of related references and identify foundational material, using the "ancestry approach" (Cooper, 1998, p. 56).

Evaluation and Selection Criteria

References are evaluated to determine relevancy and quality using criteria outlined by Bell and Smith (2009):

Authority. Authors and publishers who are affiliated with recognized academic institutions, are frequently cited, or have established professional reputations are considered authoritative. Authors and publishers who specialize in fields specific to the study are preferred.

Objectivity. Literature focusing on theories and concepts rather than products or licensed approaches are considered more objective and therefore more relevant to the study.

Quality. Well-organized, clearly worded literature citing authoritative academic sources and using detailed methodologies are considered high quality.

Coverage. Literature is determined to be relevant to the study if it aligns with the research topic and goals of the study, including audience needs. Literature that expands the areas addressed in the study by building on established theories, and whose subject matter addresses multiple search terms is considered relevant to the study. A collection of references showing multiple points of view is sought out.

Currency. Literature published within the last five years is considered current, and is collected in order to provide an overview of emerging research. Older foundation materials are included to provide definitions and context, but are not included in the literature coding and analysis process.

References that are not determined to be highly relevant or of high quality with regards to these criteria are either not selected for the study or their deficiencies are noted.

Documentation Approach

The author(s), abstract, and citations are reviewed in each reference to determine relevancy and quality, using criteria provided by Bell and Smith (2009). High-quality, relevant references are entered into the Zotero research software tool with complete bibliographic information and linked to a full-text file. Published abstracts are captured for each document, along with the researcher's own synopsis and comments. As discussed by Creswell (2009), literature maps (see Figure 1 and Figure 2) are designed to provide a visual overview of the references and identify themes and concepts (p. 34). Using the key words and literature map, a taxonomy is built to support the research study, and each reference is tagged with appropriate keywords from the taxonomy (see Table 2). Further in-text annotations and highlights are recorded in PDF documents using Adobe Acrobat.

Search term result tables. Results for each search term are recorded for specific databases, along with number of downloaded references. Table 1 shows a report on search results by database.

Literature map. As discussed by Creswell (2009, p. 34), literature maps are designed to provide a visual overview of the references and identify themes and concepts (see Figure 1 and Figure 2).

Reference database. Relevant references are entered into the Zotero research software tool with complete bibliographic information, including reference identifiers such as doi and ISBN numbers. Published abstracts are captured for each document inside the software, along with the researcher's own synopsis and comments, notations, and tags. A PDF document for each reference is saved locally and linked to each reference record. Further in-text notes and highlights are recorded inside the PDF using Adobe Acrobat.

Taxonomy. Existing tag terms are gleaned from tagged articles and combined with key words and search terms, sorted alphabetically. Duplicate terms are removed, and remaining terms are sorted by category, to produce a taxonomy (see Table 2). High-quality, relevant references are tagged with appropriate keywords from the taxonomy in the database.

Data Analysis Plan

Data coding and analysis. Selected literature is analyzed according to a conceptual analysis process, which includes a coding procedure consisting of eight parameters (Busch et al., 2005). A primary coding stage (also discussed as tagging) applies terms identified in the taxonomy (see Table 2) as tags in order to identify a highly relevant set of sources suitable for further analysis. A secondary coding stage (also discussed as factor analysis) applies deep analysis to the relevant set of sources, examining each to reveal influential cognitive and emotional factors. Specific application of each parameter for this study includes:

1. **Level of analysis.** During the primary coding stage (tagging), relevant words and phrases gathered from the search terms and initial references gathered to produce a taxonomy of key terms (see Table 2). Terms at a specified level of the heirarchy in the taxonomy (*experience design*, *design psychology*, *experiential learning*, and *museum studies*), along with terms describing the possible application of the reference (*academic application*, *business application*, *technical application*) and reference content (*definition*, *method*, *research*, *theory*), are selected as the primary coding set of terms. Each collected reference is reviewed for relevancy and quality using criteria outlined by Bell and Smith (2009) and tagged with appropriate terms from the primary coding set, in order to select a high-quality, highly-relevant set of references for deep analysis in the secondary coding stage.

During the secondary coding stage (factor analysis), references identified during the primary stage are examined in-depth to reveal specific influential cognitive and emotional factors.

2. **Number of concepts.** Preliminary concepts identified in the taxonomy (see Table 2) are used to identify a set of highly relevant sources by subject area during the primary coding stage (tagging) (see Figure 2). Primary coding concepts include: (a) experience design, (b) design psychology, (c) experiential learning, and (d) museum studies (see Table 2). Primary subject areas include (a) human interactions with information, (b) experiential learning, and (c) learning in museums (see Figure 2). Analysis during the secondary coding stage (factor analysis) identifies specific cognitive and emotional factors for each concept and subject area. Additional concepts that emerge during analysis are also included during the secondary coding stage, since "introducing a level of coding flexibility allows new, important material to be incorporated into the coding process that could have significant bearings on one's results" (Busch et al., 2005).
3. **Existence of a concept.** Concepts are coded for existence rather than frequency; if they appear in the content they are included and described in the report of coding results, rather than simply counted each time they appear.
4. **Level of generalization.** The level of generalization is determed by meaning, which is defined using the taxonomy (see Table 2). Terms and concepts with similar meanings using the same reference; similar terms with different meanings are coded separately. For example, *user experience design* and *UX* are alternative terms for *experience design*, as specified by the taxonomy.

5. **Translation rules.** Coding rules are outlined using the parent/child structure of the taxonomy (see Table 2). For example, both *experience design* and *design psychology* are identified as child entries under the parent term of *human-centered design*, and many different aspects of *experience design* (including *usability, information design*, and *interaction design*) are identified as child entries under the parent term of *experience design*. Terms and concepts at the specified level (see Table 2) are used for preliminary coding to identify a set of references suitable for deep analysis.
6. **Irrelevant information.** Qualifying words like *and* and *the* are considered irrelevant unless they alter the meaning of the term or concept. Irrelevant information, as determined by contextual reading, is not used for coding.
7. **Code the texts.** In order to gather explicit information, the initial collection of sources are reviewed and tagged with primary set of coding terms. References selected for secondary coding are also examined for implicit meaning to reveal specific cognitive and emotional factors relevant to the study.
8. A**nalyze results.** Results of the primary coding process (tagging) are recorded by author, reference date, subject areas (see Figure 2), and tags (see Table 2) and presented along with influential factors in a study results matrix (see Appendix A), in order to identify factors by subject area, note areas of subject overlap and omission, and address the research questions. Analysis results are synthesised and discussed in the manner described in the Writing Plan.

Writing Plan

Review of literature. Information distilled during data collection and analysis can include documenting the current state of research and then constructing "context based inferences" to create meaning (Obenzinger, 2005, pp. 4-5). The Review of Literature section offers an overview of current literature as it relates to research questions and creates meaning by discussing relevant factors identified through analysis.

Research results overview. An overview of current research areas and relevant factors is presented as a visual study results matrix (see Appendix A). Factors are clustered by subject area in order to reveal meaning through emerging patterns, areas of overlap, and areas of omission. Study results identified in the matrix are examined and discussed collectively, in order to build bridges between subject areas (Cooper, 1998, p. 3).

Influential factors. Influential cognitive and emotional factors identified in the study results matrix are clustered and discussed by factor group, noting possible influences on informal learning experiences in interactive environments through examination of the factor group in regards to humans, design, and other factor groups.

Design stakeholder and practitioner report. In order to serve the intended audience of design stakeholders and practitioners, a study synopsis and report on influential factors is also presented in a separate white paper, suitable for business use, included in Appendix B. A white paper can be defined as an "authoritative" and "informative" publication that "argue[s] a specific position or propose a solution to a problem" and often addresses an audience outside the originating organization (Sakamuro & Stolley, 2010). This design stakeholder and practitioner report offers a high-level study overview suitable for business use and executive review. The

white paper includes an executive summary, identified factors clustered into factor groups, definitions, an overview of research methods, and a bibliography.

Annotated Bibliography

This section presents the key references supporting the study, with published abstracts and researcher comments. Comments set the reference in the context of study parameters, and note credibility based on author and publisher credentials. Comments also list possible cognitive and emotional factors and note references selected for the secondary coding stage (factor analysis).

Allen, S. (2004). Designs for learning: Studying science museum exhibits that do more than entertain. *Science Education*, *88*(1), 17.

Abstract. Science museum staff face a constructivist dilemma as they design their public spaces: the exhibits should facilitate science learning, yet they also need to support a diverse visiting public in making their own personal choices about where to attend, what to do, and how to interpret their interactions. To be effective as teaching tools, exhibits need to be highly intrinsically motivating at every step of an interaction in order to sustain involvement by an audience who views their visit primarily as a leisure activity [sic]. Given these challenges, it is vital to support the design process with a strong program of research and evaluation. I give a personal perspective on one institution's research and evaluation work over the last decade, focusing on four areas: immediate apprehendability, physical interactivity, conceptual coherence, and diversity of learners [sic].

Comments. Allen (2004) provides a case study of exhibit design over the past 10 years for the Exploratorium, a science museum. She notes four areas of importance: "immediate apprehendability, physical interactivity, conceptual

coherence, and diversity of learning modes" (Ibid, p. S29). All these areas can be addressed with greater attention to user-centered design processes. Although it is assumed that greater interactivity provides a richer experience, "gratuitous interactivity" may actually detract from an experience and may hinder understanding of a specific scientific phenomena (Ibid, p. S30). She suggests continued study in the area of non-verbal forms of learning. Although storytelling and narrative approaches have been successful in emotion-based exhibits (such as history museums) this approach has been "relatively ineffective at enhancing learning or personal meaning-making at phenomenon-based exhibits" (such as science museums) (Ibid, p. S30). She suggests that because effective design is based on unique material and visitors, successful exhibits will always rely on an iterative cycle of research, prototyping and evaluation. The author, Sue Allen, is Founding Director of the Exploratorium, a hands-on science museum in San Francisco, California. This reference is a peer-reviewed journal article published within the last 10 years and is selected for factor analysis. Associated subject areas are: experience design, design psychology, experiential learning, and museum education. Possible cognitive and emotional factors include: "immediate apprehendability, physical interactivity, conceptual coherence, and diversity of learning modes" (Ibid, p. S29), "gratuitous interactivity" (Ibid, p. S30), storytelling, and narrative.

Alonso-Ríos, D., Vázquez-García, A., Mosqueira-Rey, E., & Moret-Bonillo, V. (2010). Usability: A critical analysis and a taxonomy. *International Journal of Human-*

Computer Interaction, *26*(1), 53-74. doi:10.1080/10447310903025552

Abstract. A major obstacle to the implantation of User-Centered Design in the real world is the fact that no precise definition of the concept of usability exists that is widely accepted and applied in practice. Generally speaking, the literature tends to define usability in overly brief and ambiguous terms and to describe its application in informal terms. This is one of the main reasons why ad hoc techniques predominate in usability study methodologies. The aims of this article are to investigate the concept of usability and to describe it by means of a detailed taxonomy that is organized hierarchically and that contains exhaustive descriptions of usability attributes. This taxonomy can be used to support different stages in the development of usable systems.

Comments. Alonso-Ríos, Vázquez-García, Mosqueira-Rey, and Moret-Bonillo (2010) propose a taxonomy to define aspects of usability, in order to provide a consistent framework for testing, designing, and evaluating usable systems and products. Alonso-Ríos et al. identify six parent-level or "generic" attributes, including: *knowability, operability, efficiency, robustness, safety,* and *subjective satisfaction* (2010, p. 56). The authors are affiliated with the Department of Computer Science at the University of A Coruña, Spain. This reference is a peer-reviewed journal article published within the last year and is selected for factor analysis. Associated subject areas are: experience design. Possible cognitive and emotional factors include: "knowability" (2010, pp. 56-58) and "subjective satisfaction" (2010, pp. 62-63).

Birchfield, D., Mechtley, B., Hatton, S., & Thornburg, H. (2008). Mixed-reality learning in the art museum context. In *Proceeding of the 16th ACM international conference on multimedia* (pp. 965-968). Vancouver, British Columbia, Canada: ACM.

Abstract. We describe the realization of two interactive, mixed-reality installations arising from a partnership of K-12, university, and museum participants. Our goal was to apply emerging technologies to produce an innovative, hands-on arts learning experience within a conventional art museum. *Suspended Animation, a Reflection on Calder* is a mixed-reality installation created in response to a sculpture by Alexander Calder. *Another Rack for Peto* was created in response to a painting by John Frederick Peto. Both installations express formal aspects of the original artworks, and allow visitors to explore specific conceptual themes through their interactions. The project culminated in a six-month exhibition where the original artworks were presented alongside these new installations. We present data that the installations were well received by an audience of 25,000 visitors.

Comments. Birchfield, Mechtley, Hatton and Thornburg (2008) present a case study for integrating interactive, mixed media installations into a traditional art museum. They attempted to create a meaningful experience, engage transient participants, and refrain from overwhelming the original, referenced artwork using approaches from contemporary learning theories, including active, collaborative, and constructionist learning (Ibid, p. 965). They created two installations referencing a sculpture and a painting and collected data from

visitors and staff to gauge the project's success. They believe interactivity increased time spent in the exhibits and attracted new visitors. The authors are faculty at or associated with the Arts, Media, and Engineering department at Arizona State University. The reference is a scholarly conference paper published by the Association for Computing Machinery (ACM) within the last 5 years and is selected for factor analysis. Associated subject areas are: experience design, design psychology, experiential learning, and museum education. Possible cognitive and emotional factors include: engagement, interactivity.

Damazio, V., Dal Bianco, B., Lima, J., & Menezes, C. (2009). Design and emotion: Some thoughts on users, things, and feelings. In *Rigor and Relevance in Design*. Presented at the IASDR 2009, Seoul, Korea: International Association of Societies of Design Research (IASDR).

Abstract. Emotion is one of the most overused words of the moment in contemporary world and has become part of design vocabulary, associated with products that seek to provide pleasurable experiences and to establish emotional relationships with their users [8, 9] [sic]. The study of emotion in the field of Design is, thus, new and has been conducted through various methodological approaches and through discussion with authors from an equally wide range of disciplines. The aim of this paper is to offer a theoretical reflection on the emotional relationship of users with the designed environment from an anthropological point of view. It will examine three special situations: (1) using a

product designed in partnership; (2) using something for the first time; (3) and brands that bring back good memories.

Comments. Damazio, Bianco, Lima, and Menezes (2009) propose "a theoretical reflection on the emotional relationship of users with the designed environment from an anthropological point of view" (2009, p. 2727). They suggest co-authorship, self-dependence, and memorability work to knit emotions to design artifacts, resulting in emotional attachments to experiences and the products associated with them. Design in partnership/co-authorship includes the idea of "doing 'with' as opposed to 'for' people" (Ibid, p. 2729) as being a powerful emotional experience. Self-dependent experiences occur because individual choice is emotional and empowering. Memorability is the result of first time experiences creating "somatic markers" (Ibid, p. 2732). Damazio et al. believe these attributes suggest an emotion-based design approach, in order to better serve users and society (Ibid, p. 2733). This reference is a scholarly conference paper published by the International Association of Societies of Design Research (IASDR) within the last 5 years and is selected for factor analysis. Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: co-authorship, self-dependence, and memorability.

Forlizzi, J., & Ford, S. (2000). The building blocks of experience: an early framework for interaction designers. In *Proceedings of the 3rd conference on designing interactive systems: Processes, practices, methods, and techniques* (pp. 419-423). New York City, New York, United States: ACM. doi:10.1145/347642.347800

Abstract. Design activity has recently attempted to embrace designing the user experience. Designers need to demystify how we design for user experience and how the products we design achieve specific user experience goals. This paper proposes an initial framework for understanding experience as it relates to user-product interactions. We propose a system for talking about experience, and look at what influences experience and qualities of experience. The framework is presented as a tool to understand what kinds of experiences products evoke.

Comments. Forlizzi and Ford (2000) propose "a theory of interaction design, rooted in human experience…complete with strategies for making the theory live in practice" (p. 419). They define "experience" via Richard Carlson's Experienced Cognition theory, "having an experience" via John Dewey's *Art as Experience*, and "experience as story" via Roger Shank's information architecture research (p. 419-420). Influences on experience include users (people influencing experience) and products (artifacts influencing experience) and user-product interactions. Qualities of experience are often described as useful or pleasant, but future HCI design will need to offer more in order to compete in what Pine and Gilmore call the "economy of experience" (p. 421). They propose an experience framework based on sub-consciousness, cognition, narrative, and storytelling. This reference is a scholarly conference paper published within the last 10 years and is selected for factor analysis. Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: sub-conscious experience, cognition, narrative, and storytelling.

Gilroy, S. W., Cavazza, M., & Benayoun, M. (2009). Using affective trajectories to describe states of flow in interactive art. In *Proceedings of the International Conference on Advances in Computer Entertainment Technology* (pp. 165-172). Athens, Greece: ACM.

Abstract. Interactive Art installations often integrate sophisticated interaction techniques with visual presentations contributing to a rich user experience. They also provide a privileged environment in which to study user experience by using the same sensing data that support interaction. In this paper, using the affective interface of an Augmented Reality Art installation, we introduce a framework relating real-time emotional data to phenomenological models of user experience, in particular the concept of Flow. We propose to analyse trajectories of affect in a continuous emotional space (Pleasure-Arousal-Dominance), to characterize user experience. Early experiments with several subjects interacting in pairs with the installation support this mapping on the basis of Flow questionnaires. This approach has potential implications for the analysis of user experience across Art and Entertainment applications.

Comments. Gilroy, Cavazza, and Benayoun (2009) are "interested in flow as a reflection of user experience" (p. 169) and seek to track affective response during user experiences within the context of an interactive art installation. The authors suggest art experiences can induce a flow state, noting "ability to channel ones skills into affecting the outcome of an experience is important for flow when that experience is interactive in nature" (Ibid, p. 168). Gilroy and Cavazza are affiliated with Teesside University and Benayoun is affiliated with CiTu

Université Paris. This reference is a peer-reviewed journal article published within the last 2 years and is not selected for factor analysis, due to partial focus on augmented realities and gaming. Associated subject areas are: experience design, design psychology. Possible cognitive and emotional factors include: pleasure, arousal, dominance, flow.

Hassenzahl, M., & Ullrich, D. (2007). To do or not to do: Differences in user experience and retrospective judgments depending on the presence or absence of instrumental goals. *Interact. Comput.*, *19*(4), 429-437.

Abstract. Recently, Human-Computer Interaction (HCI) started to focus on experiential aspects of product use, such as affect or hedonic qualities. One interesting question concerns the way a particular experience is summarized into a retrospective value judgment about the product. In the present study, we specifically explored the relationship between affect, mental effort and spontaneity experienced while interacting with a storytelling system and retrospective judgments of appeal. In addition, we studied differential effects of the presence or absence of instrumental goals. In general, active instrumental goals did not only impact experience per se by, for example, inducing mental effort, but also the way subsequent retrospective judgments were formed. We discuss the implications of our findings for the practice of product evaluation in HCI specifically, and more general aspects, such as the role of affect in product evaluations and the importance of usage mode compatibility (i.e., a compatibility of the way one ought to and actually does approach a product).

Comments. Hassenzahl and Ullrich (2007) examine the roles of "affect, mental effort, and spontaneity" in user experiences. They suggest "interaction with a product, no matter whether goal or not goal-oriented, is inevitably accompanied by affect" but found that users rank affect, mental effort and spontaneity differently in goal-driven interactions (where specific tasks are assigned) than in non-goal driven interactions (where users are self-directed) (2007, p. 435) . Hassenzahl is associated with the Economic Psychology and Human-Computer Interaction department at the University of Koblenz-Landau, Germany, and Ullrich studies Social Psychology and Decision Making at Darmstadt University of Technology. This reference is a peer-reviewed journal article published within the last 3 years and is selected for factor analysis. Associated subject areas are: experience design, design psychology, and experiential learning. Possible cognitive and emotional factors include affect, mental effort, and spontaneity.

Hatala, M., & Wakkary, R. (2005). Ontology-based user modeling in an augmented audio reality system for museums. *User Modeling and User-Adapted Interaction*, *15*(3-4), 339-380. doi:10.1007/s11257-005-2304-5

Abstract. Ubiquitous computing is a challenging area that allows us to further our understanding and techniques of context-aware and adaptive systems. Among the challenges is the general problem of capturing the larger context in interaction from the perspective of user modeling and human---computer interaction (HCI). The imperative to address this issue is great considering the emergence of ubiquitous and mobile computing environments. This paper provides an account

of our addressing the specific problem of supporting functionality as well as the experience design issues related to museum visits through user modeling in combination with an audio augmented reality and tangible user interface system. This paper details our deployment and evaluation of ec(h)o --- an augmented audio reality system for museums. We explore the possibility of supporting a context-aware adaptive system by linking environment, interaction objects and users at an abstract semantic level instead of at the content level. From the user modeling perspective ec(h)o is a knowledge-based recommender system. In this paper we present our findings from user testing and how our approach works well with an audio and tangible user interface within a ubiquitous computing system. We conclude by showing where further research is needed.

Comments. Hatala and Wakkary (2005) discuss user interfaces for technology-driven museum guides, in the context of interactions as viewed in human-computer interaction (HCI) theory and user experience design. They note “the factors within museum experiences are social, cultural, historical, and psychological" (2005, p. 340) and categorize the museum experience as “multivariate” (2005, p. 341). The authors are associated with the School of Interactive Arts and Technology at Simon Fraser University. This reference is a peer-reviewed journal article published within the last 5 years and is not selected for factor analysis, due to the research focus on a specific, branded technology product. Associated subject areas are: experience design, experiential learning, and museum education.

Hein, G. E. (2004). John Dewey and museum education. *Curator*, *47*(4), 413-427.

Abstract. Although John Dewey's educational concepts have been discussed previously in relation to museums, his own writing about museums has received little attention. Dewey, who visited museums frequently throughout his life, recognized the powerful educational value of museums. He assigned a central role to museums as integrative components of raw experiences in his educational theory, and he made extensive use of student visits to museums at the Chicago Laboratory School. Early twentieth-century museum educators and directors applied Dewey's ideas, and advocated a museum education philosophy, based on the progressive education movement, that has significance for current exhibition and educational practice.

Comments. Hein (2004) notes that Dewey's emphasis on the educational power of museums as informal learning environments influenced early 20th century museum educational philosophy and design. He proposes that this approach has significance for current practice. Hein believes museum learning should "lead to inquiry and…guide visitors to apply the results of such inquiry to life situations" (Ibid, p. 424). This reference is a peer-reviewed journal article published within the last 10 years and is selected for factor analysis. Associated subject areas are: experiential learning and museum education. Possible cognitive and emotional factors include: lead and applied inquiry.

Hennes, T. (2002). Rethinking the visitor experience: Transforming obstacle into purpose. *Curator*, *45*(2), 109-121.

Abstract. The purposes of museums and those of their visitors often have little in common—despite the growing body of knowledge about museum learning and visitors' motivations. Based on concepts of experiential learning envisioned a century ago by the American educator and philosopher John Dewey, this paper explores bringing those purposes into closer alignment. A re-evaluation of several factors—including criteria of experience, content organization, and the nature of inquiry—could lead to exhibitions more closely aligned with visitors' processes of self-motivated activity and museums' goals for informal learning. One way is to shape exhibits and activity around problematical situations developed out of the exhibit experience itself and shaped by visitors' own purposes. By shifting focus from knowledge taxonomies to problem-solving situations, museums could increase their exhibitions' potential for providing engaging educational experiences to visitors.

Comments. Hennes (2002) proposes that Dewey's experiential learning theory can be used to bring museum and visitor purposes into closer alignment. He suggests "shifting focus from knowledge taxonomies to problem-solving situations" and designing around experience, content organization, and the nature of inquiry (Ibid, p. 105). Hennes suggests museum design should focus on Dewey's notion of continuity of experience, promoting future educational inquiry. The author, Tom Hennes, is the principle of Thinc Design. This reference is a peer-reviewed journal article published within the last 10 years and is selected for factor analysis. Associated subject areas are: experiential learning and museum education. Possible cognitive and emotional factors include: continuity of

experience, nature of inquiry.

Hornecker, E., Marshall, P., & Rogers, Y. (2007). From entry to access. In *Proceedings of the 2007 conference on designing pleasurable products and interfaces - DPPI '07* (p. 328-342). Presented at the 2007 conference, Helsinki, Finland. doi:10.1145/1314161.1314191

Abstract. Shareability is a design principle that refers to how a system, interface, or device engages a group of collocated, co-present users in shared interactions around the same content (or the same object). This is broken down in terms of a set of components that facilitate or constrain the way an interface (or product) is made shareable. Central are the notions of access points and entry points. Entry points invite and entice people into engagement, providing an advance overview, minimal barriers, and a honeypot effect that draws observers into the activity. Access points enable users to join a group's activity, allowing perceptual and manipulative access and fluidity of sharing. We show how these terms can be useful for informing analysis and empirical research.

Comments. Hornecker, Marshall and Rogers (2007) present the idea of "shareability" defined as a "design principle that refers to how a system, interface, or device engages a group of collocated, co-present users in shared interactions around the same content (or the same object)" (p. 328), and provide examples of shareability in a museum context. Shareability can be created through the use of user entry points, access points, and the "honeypot effect" (p. 330). Hornecker, Marshall and Rogers are affiliated with the Pervasive Interaction Lab

at The Open University, Milton Keynes. This reference is part of the Proceedings of the 2007 conference on Designing Pleasurable Products and Interfaces (DPPI '07) at the University of Art and Design in Helsinki, Finland. The reference is selected for factor analysis. Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: shareability, entry point, access point, and honeypot effect.

Jordan, M. (2010). The meaning of affinity and the importance of identity in the designed world. *interactions*, *17*(5), 6. doi:10.1145/1836216.1836218

Introduction. When a designer is thinking about ways to create experiences that deliver meaningful and lasting connections to users, it is helpful to consider the notion of our personal affinities and how they affect perception, adoption, and use in the designed world. The term "affinity," when illuminated by definitions from chemistry and biology, gives us a deeper understanding of the form and importance of these connections people have to products and services. An exploration of what affinity means can lead us to consider new and useful ways of informing design thinking and ultimately help us design with more success.

Comments. Jordan (2010) is a research and design consultant who holds an MA in Professional Writing and Communication Design from Carnegie Mellon University. This reference is a peer-reviewed magazine article published by ACM within the last 5 years and is selected for factor analysis. Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: affinity, identity.

Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. (2001). Experiential learning theory: Previous research and new directions. In *Perspectives on thinking, learning, and cognitive styles* (pp. 227–247). Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

Introduction. Experiential Learning Theory (ELT) provides a holistic model of the learning process and a multilinear model of adult development, both of which are consistent with what we know about how people learn, grow, and develop. The theory is called "Experiential Learning" to emphasize the central role that experience plays in the learning process, an emphasis that distinguishes ELT from other learning theories. The term "experiential" is used therefore to differentiate ELT both from cognitive learning theories, which tend to emphasize cognition over affect, and behavioral learning theories that deny any role for subjective experience in the learning process. Another reason the theory is called "experiential" is its intellectual origins in the experiential works of Dewey, Lewin, and Piaget. Taken together, Dewey's philosophical pragmatism, Lewin's social psychology, and Piaget's cognitive-developmental genetic epistemology form a unique perspective on learning and development (Kolb, 1984).

Comments. Kolb's Experiential Learning Theory (ELT), introduced in 1984, is a contemporary learning theory that emphasizes the "central role experience plays in the learning process" (Kolb et al., 2001, p. 227). Kolb, et al. (2001) provide an overview of the original theory and an update on current research and theory, along with a definition of ELT's history and future as "creative exploration of the

links among experience, learning, and development across the social spectrum" (Kolb et al., 2001, p. 249). ELT differs from cognitive learning theory, which "emphasizes cognition over affect," and behavioral learning, which denies that objective experience has a role in learning (Kolb et al., 2001, p. 227). ELT suggests learning happens through a process of *grasping* concrete experiences (CE) and abstract concepts (AC) and *transforming* them through active experimentation (AE) or reflective observation (RO) (Kolb et al., 2001, p. 228). Human preferences for recognizing and integrating information are known as learning styles, which ELT categorizes as diverging, assimilating, converging, or accommodating (Kolb et al., 2001, pp. 229-231). Recently ELT has intersected with integrated learning theory, an idealized concept of learning as a "spiral" of experiencing, reflecting, thinking, and acting in active response to a learning situation (Kolb et al., 2001, p. 240). The degree to which learners apply styles holistically is known as *adaptive learning*; sophisticated learners apply learning styles in all four areas in an "adaptively flexible" way (Kolb et al., 2001, p. 244). Applying Kolb's Learning Skills Profile (LSP) and the Adaptive Style Inventory (ASI) helps to rank learners into second-order (using multiple styles) or third-order (balanced) styles. ELT, especially as it applies to adaptive learning, is of particular interest for interactive environments, which are inherently self-directed and can potentially serve a variety of learning styles simultaneously. A possible cognitive and emotional factor is: *integrated learning* through a "spiral" of experiencing, reflecting, thinking, and acting (Kolb et al., 2001, p. 240). This reference is a peer-reviewed article published within the last 10 years and is

selected for factor analysis. Associated subject areas are: experience design and experiential learning. Possible cognitive and emotional factors include: learning styles, integrated learning theory, adaptive learning.

Lake-Hammond, A., & Waite, N. (2010). Exhibition design: Bridging the knowledge gap. *Design Journal*, *13*(1), 77-98.

Abstract. This article considers the changing role of exhibition design and its contribution to interpretation in the increasingly audience-centred museum environment. By examining the case of the Museum of New Zealand/Te Papa Tongarewa, this article considers the designers' creative role in framing the problem and connecting with the needs and desires of potential users to reshape both the institution of the museum and visitors' experience. This article concludes with a preliminary map of the key interpretive design considerations of concepts, contexts and narratives as a guide to the exhibition design process in contemporary museums, and for those who seek to bridge the gap between expert knowledge and public audiences. This creative interdisciplinary role for design in bridging the gap between growing expert knowledge and satisfying an increasing desire for democratic participation in its dissemination can be seen as an important cultural role for design and one worthy of further critical consideration.

Comments. Lake-Hammond and Waite (2010) examine the designer’s role in shaping museum experiences through a case study of a single museum. They stress the importance of “involving designers in a dialogue with the museum community and treating exhibitions as communication problem spaces” and how

the role of the exhibition designer has evolved from display artist to interior designer to interaction designer and even information architect (Lake-Hammond & Waite, 2010, p. 93). The reference is a collaboration between Alice Lake-Hammond, a freelance designer, and Noel Waite, who is affiliated with the University of Otago in New Zealand. This reference is a peer-reviewed journal article published within the last year and is selected for factor analysis. Associated subject areas are: experience design, design psychology, and museum education. Possible cognitive and emotional factors include: concepts, contexts, and narratives.

Lamb, R., & Kling, R. (2003). Reconceptualizing users as social actors in information systems research. *MIS quarterly*, *27*(2), 197-236.

Abstract. A concept of the user is fundamental to much of the research and practice of information systems design, development, and evaluation. Usercentered [sic] information studies have relied on individualistic cognitive models to carefully examine the criteria that influence the selection of information and communication technologies (ICTs) that people make. In many ways, these studies have improved our understanding of how a good information resource fits the people who use it. However, research approaches based on an individualistic user concept are limited. In this paper, we examine the theoretical constructs that shape this user concept and contrast these with alternative views that help to reconceptualize the user as a social actor. Despite pervasive ICT use, social actors are not primarily users of ICTs. Most people who use ICT applications utilize

multiple applications, in various roles, and as part of their efforts to produce goods and services while interacting with a variety of other people, and often in multiple social contexts. Moreover, the socially thin user construct limits our understanding of information selection, manipulation, communication, and exchange within complex social contexts. Using analyses from a recent study of online information service use, we develop an institutionalist concept of a social actor whose everyday interactions are infused with ICT use. We then encourage a shift from the user concept to a concept of the social actor in IS research. We suggest that such a shift will sharpen perceptions of how organizational contexts shape ICT-related practices, and at the same time will help researchers more accurately portray the complex and multiple roles that people fulfill while adopting, adapting, and using information systems.

Comments. Lamb and Kling (2003) acknowledge the cognitive influences that have shaped the current individualist concept of the user in information system research, but they argue that the user functions in a complex social and organizational environment that shapes behavior as well. Recognizing the user as a social actor re-contextualizes user experience as interdependent and requires new approaches for information system research and design. These theories relate to foundational work by Nass, Steuer, and Tauber, (1994) which classifies human-computer interaction as a social experience, and computers themselves as social actors. This reference is a peer-reviewed article published within the last 10 years and is not selected for factor analysis, due to reference age. Associated subject areas are: experience design and design psychology.

Love, T. (2009). Design and emotion: Time for a new direction? In *Rigor and Relevance in Design*. Presented at the IASDR 2009, Seoul, Korea: International Association of Societies of Design Research (IASDR).

Abstract. This paper describes research investigating why the extensive effort in Design and Emotion research and publications has not had more significant effect in improving design theory and practice in spite of the large amounts of funding expended, the number of research projects and research centers and the large number of publications. The analyses point to two foundational research issues that appear to have been overlooked and which point to why Design and Emotion research culture is failing to make radical and significant impacts on design theory, design research, design practice and design education across all the major fields of design in the art and design, technical design and other design sectors. The paper concludes with a brief outline of the changes likely to make the Design and Emotion field more effective in improving design outcomes, design practice, design research and design theory.

Comments. Love (2009) outlines the limited effect studies of emotion in design have had on design practices, despite growing interest in and funding for the area. In order to contribute to contemporary design theory and develop practical guidelines, Love suggests the design and emotion field should reconsider design as part of an integrated activity with relationships to science disciplines and incorporate current cognitive neuroscience findings in order to reconsider the meaning of “emotion”. This reference is a scholarly conference paper published

within the last 5 years and is not selected for factor analysis, due to focus on directions for the field rather than specific factors for designers. Associated subject areas are: experience design and design psychology.

Nass, C., Steuer, J., & Tauber, E. R. (1994). Computers are social actors. In *Proceedings of the SIGCHI conference on Human factors in computing systems: celebrating interdependence* (pp. 72-78). Boston, Massachusetts, United States: ACM. doi:10.1145/191666.191703

Abstract. This paper presents a new experimental paradigm for the study of human-computer interaction. Five experiments provide evidence that individuals' interactions with computers are fundamentally social. The studies show that social responses to computers are not the result of conscious beliefs that computers are human or human-like. Moreover, such behaviors do not result from users' ignorance or from psychological or social dysfunctions, or [sic] from a belief that subjects are interacting with programmers. Rather, social responses to computers are commonplace and easy to generate. The results reported here present numerous and unprecedented hypotheses, unexpected implications for design, new approaches to usability testing, and direct methods for verification.

Comments. Nass, Steuer, and Tauber (1994) classify human-computer interaction as a social experience, and computers themselves as social actors. This reference is a scholarly conference paper published within the last 20 years and is not selected for factor analysis, due to the age of the reference. Associated subject areas are: experience design and design psychology.

Norman, D. (2002). Emotion & design: attractive things work better. *interactions*, *9*(4), 36-42. doi:10.1145/543434.543435

Abstract. Good human-centered design practices are most essential for tasks or situations that are stressful: distractions, bottlenecks, and irritations need to be minimized. In pleasant, positive situations, people are much more likely to be tolerant of minor difficulties and irrelevancies. In other words, although poor design is never excusable, when people are in a relaxed situation, the pleasant, pleasurable aspects of the design will make them more tolerant of difficulties and problems in the interface. [From reference body]

Comments. The author, Don Norman, is a consultant, author, and professor of computer science at Northwestern University. The reference (2002) is part of Norman's book, *Emotional Design: Why We Love or Hate Everyday Things* (2004), and is useful because it addresses the concepts of emotion, affect, and design in a reference that is suitable for coding. This reference is a peer-reviewed journal article published within the last 10 years and is selected for factor analysis. Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: beauty, usability, and positive affect.

Norman, D. A., Ortony, A., & Russell, D. M. (2003). Affect and machine design: Lessons for the development of autonomous machines. *IBM Systems Journal*.

Abstract. Human beings have evolved a rich and sophisticated set of processes

for engaging with the world in which cognition and affect play two different but equally crucial roles. Cognition interprets and makes sense of the world. Affect evaluates and judges, modulating the operating parameters of cognition and providing warning of possible dangers. The study of how these two systems work together provides guidance for the design of complex autonomous systems that must deal with a variety of tasks in a dynamic, often unpredictable, and sometimes hazardous environment.

Comments. Norman, Ortony and Russell (2003) discuss the differences between cognition and affect and define the terms. Cognition "interprets and makes sense of the world" while affect "evaluates and judges, modulating the operating parameters of cognition and providing warning of possible dangers" (2003, p. 38). This reference is a peer-reviewed article published within the last 10 years and is not selected for factor analysis due to content focus on machine design. This reference is useful for providing non-technical definitions of "cognition" and "affect". Associated subject areas are: experience design and design psychology.

O'Brien, H. L., & Toms, E. G. (2008). What is user engagement? A conceptual framework for defining user engagement with technology. *Journal of the American Society for Information Science and Technology*, *59*(6), 938-955. doi:10.1002/asi.20801

Abstract. The purpose of this article is to critically deconstruct the term engagement as it applies to peoples' experiences with technology. Through an extensive, critical multidisciplinary literature review and exploratory study of

users of Web searching, online shopping, Webcasting, and gaming applications, we conceptually and operationally defined engagement. Building on past research, we conducted semistructured interviews with the users of four applications to explore their perception of being engaged with the technology. Results indicate that engagement is a process comprised of four distinct stages: point of engagement, period of sustained engagement, disengagement, and reengagement. Furthermore, the process is characterized by attributes of engagement that pertain to the user, the system, and user-system interaction. We also found evidence of the factors that contribute to nonengagement. Emerging from this research is a definition of engagement—a term not defined consistently in past work—as a quality of user experience characterized by attributes of challenge, positive affect, endurability, aesthetic and sensory appeal, attention, feedback, variety/novelty, interactivity, and perceived user control. This exploratory work provides the foundation for future work to test the conceptual model in various application areas, and to develop methods to measure engaging user experiences.

Comments. O'Brien and Toms (2008) define engagement with technology as "a quality of user experience characterized by attributes of challenge, positive affect, endurability, aesthetic and sensory appeal, attention, feedback, variety/novelty, interactivity, and perceived user control" (2008, p. 938). The author(s) are Heather L. O'Brien (School of Library, Archival and Information Studies, University of British Columbia) and Elaine G. Toms (School of Business Administration, Dalhousie University). This reference is a peer-reviewed article

published within the last 5 years and is not selected for factor analysis, due to inclusion in later work by O'Brien and Toms (2010). Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: engagement.

O'Brien, H. L., & Toms, E. G. (2010). The development and evaluation of a survey to measure user engagement. *Journal of the American Society for Information Science and Technology*, *61*(1), 50-69.

Abstract. Facilitating engaging user experiences is essential in the design of interactive systems. To accomplish this, it is necessary to understand the composition of this construct and how to evaluate it. Building on previous work that posited a theory of engagement and identified a core set of attributes that operationalized this construct, we constructed and evaluated a multidimensional scale to measure user engagement. In this paper we describe the development of the scale, as well as two large-scale studies (N=440 and N=802) that were undertaken to assess its reliability and validity in online shopping environments. In the first we used Reliability Analysis and Exploratory Factor Analysis to identify six attributes of engagement: Perceived Usability, Aesthetics, Focused Attention, Felt Involvement, Novelty, and Endurability. In the second we tested the validity of and relationships among those attributes using Structural Equation Modeling. The result of this research is a multidimensional scale that may be used to test the engagement of software applications. In addition, findings indicate that attributes of engagement are highly intertwined, a complex interplay of user-

system interaction variables. Notably, Perceived Usability played a mediating role in the relationship between Endurability and Novelty, Aesthetics, Felt Involvement, and Focused Attention.

Comments. O'Brien and Toms (2010) note "facilitating engaging user experiences is essential in the design of interactive systems" and the study describes six attributes of experience: "Perceived Usability, Aesthetics, Focused Attention, Felt Involvement, Novelty, and Endurability" and the relationships between these attributes (2010, p. 50). The author(s) are Heather L. O'Brien (School of Library, Archival and Information Studies, University of British Columbia) and Elaine G. Toms (School of Business Administration, Dalhousie University). This reference is a peer-reviewed article published within the last year and is selected for factor analysis. Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: perceived usability, aesthetics, focused attention, felt involvement, novelty, and endurability.

Polaine, A. (2005). The flow principle in interactivity. In *Proceedings of the second Australasian conference on Interactive entertainment* (pp. 151-158). Sydney, Australia: Creativity & Cognition Studios Press.

Abstract. This paper argues that true interactivity is a feedback loop of action-reaction-interaction and involves collaboration or exchange (with real or computer agents). Central to this argument is physical interactivity as a defining feature of new media in addition to the psychological interaction with a work as

Lev Manovich [27] describes. It is also argued that interactivity will always remain opposed to traditional narrative forms, but that a similar engagement and willing suspension of disbelief are equally important within interactive works if explored on interactivity's own terms, especially through an understanding of play. The psychologist Mihaly Csikszentmihalyi [12, 13] has written extensively on the intrinsic pleasures of creative action and argues that activities can be rewarding in and of themselves, regardless of any goals or outcomes. Csikszentmihalyi describes this theory of the autotelic experience as the flow principle and it relates directly to the engagement with interactive experiences. Case studies are cited in which the flow principle can be applied to interactivity and shows that engagement may begin and end with playful experiences that are satisfying in their own right. [sic]

Comments. Polaine (2005) suggests interactivity is comprised of both physical and psychological interactions in a collaborative "feedback loop" (p. 151). Polaine (2005) relates Csikszentmihalyi's flow principle to user engagement and proposes that "playful" experiences facilitate engagement (p. 151). Polaine (2005) suggests studying interactive experiences further, in order to develop principles of interactivity for designers in the way that storytellers use principles of narrative (p. 157). The author, Andrew Polaine, is associated with the University of New South Wales and University of Technology, in Sydney. This reference is a peer-reviewed journal article published within the last 5 years and is selected for factor analysis. Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: engagement, suspension of

disbelief, playfulness, and flow.

Renninger, K. (2009). Interest and identity development in instruction: An inductive model. *Educational Psychologist*, *44*(2), 105-118. doi:10.1080/00461520902832392

Abstract. An inductive model is proposed that suggests that support for the development and deepening of interest can be aided by knowledge of identity development. The model suggests that instructional practice would be usefully informed were educators (e.g., teachers, parents, museum curators, counselors) to have information about both the phase of a learner's interest and age-related expectations about their identity development, when working to promote learning of particular disciplinary content. Research describing phases in the development of interest and the age-related challenges and expectations specific to self-representation is reviewed, followed by evidence from the literature that provides preliminary support for the model. Research directions needed to challenge and refine the model follow.

Comments. Renninger (2009) defines interest as "a learner's predisposition to reengage particular disciplinary content over time" (rather than simple vocational interest) and identity as "the learner's self-representation as a person who pursues particular content and the processes that inform the development of this self-representation" (p. 106). Renninger notes that "identity, like interest, develops through interactions" and proposes that understanding learner's phase of interest and identity development aids in instruction (Ibid). The author, K. Ann

Renninger, is affiliated with Department of Educational Studies at Swarthmore College. This reference is a peer-reviewed journal article published within the last two years and is selected for factor analysis. Associated subject areas are: design psychology and experiential learning. Possible cognitive and emotional factors include: interest phase, identity.

Van Nimwegen, C., Van Oostendorp, H., Burgos, D., & Koper, R. (2006). Does an interface with less assistance provoke more thoughtful behavior? In *Proceedings of the 7th international conference on learning sciences* (pp. 785-791). Bloomington, Indiana: International Society of the Learning Sciences.

Abstract. This paper investigates effects of interface style and cognitive style on problem solving performance. It is often assumed that performance improves when information is externalized onto the interface. Although relieving working memory this may discourage planning, understanding and knowledge acquisition. When information is not externalized, it must be internalized, stored in the user's memory, requiring more planning and thinking, perhaps leading to better performance and knowledge. Another variable influencing behavior is the cognitive style of users. We included "Need for Cognition" (NFC), the tendency to engage in cognitive tasks. We investigated the effects of interface style and NFC using planning tasks. The internalization interface led to more planful behavior and smarter solutions, but NFC had no effect. Understanding reactions to interface information is crucial in designing software aimed at education and learning. To facilitate active learning and provoke better performance, designers should take care in giving users (too) much assistance.

Comments. Van Nimwegen, Van Oostendorp, Burgos, and Koper (2006) attempt to "[build] bridges between cognitive science, human computer interaction and educational practices" (p. 791) through studying the "effects of interface style and cognitive style on problem solving performance" (Ibid, p. 785). Although many systems "externalize" information onto an interface to relieve cognitive processes, van Nimwegen et al. suggest "designers could consider making interactions "less assisted" to persuade users into specific behavior" (Ibid, p. 790). Christof van Nimwegen and Herre van Oostendorp are affiliated with Utrecht University; Daniel Burgos and Rob Koper with Open University of the Netherlands. This reference is a peer-reviewed journal article published within the last 5 years and is selected for factor analysis. Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: externalization, internalization, "planfulness" (p. 790), engagement, usability, and satisfaction.

Van Moer, E., De Mette, T., & Elias, W. (2008). From obstacle to growth: Dewey's legacy of experience-based art education. *International Journal of Art & Design Education*, *27*(1), 43-52. doi:10.1111/j.1476-8070.2008.00556.x

Abstract. In the last decades theories that emphasise visitors' experience as the key element in the process of meaning-making have influenced art education in museums considerably. However, there is remarkably little evidence in practice that museums shape their exhibits and educational tools by the actual experiences of visitors. Because museum education is still too much knowledge-based, people

often do not come to understanding or engagement of thinking. This article demonstrates this inconsistency and its consequences based on visitors' conversations during a museum visit while looking at contemporary art. In order to engage visitors into their own thinking and create lasting experiences, the article also investigates Dewey's ideas about experienced-based education and inquiry learning. The study especially shows that experiences felt as obstacles for interpretation are extremely suitable to stimulate, deepen and improve visitors' engagement in the inquiry cycle.

Comments. Van Moer, De Mette, and Elias (2008) report that despite recent focus on the importance of visitor experiences, museums "prefer communicating predefined messages (the goal of information-based exhibits) than design[ing] educational tools concentrating on genuine experiences of viewers (the goal of experience-based exhibits)" (p.44). This hinders learning because "information-based exhibits often create reactions without personal engagement and develop experiences not meaningful enough to capture visitors' attention and open up to further growth" (Ibid). Van Moer et al. suggest museums follow Dewey's model of experiential learning, and cite contemporary research to support this (Ibid). Eva Van Moer and Tom De Metter are researchers; Willem Elias is a professor and chairman at the department of Adult Educational Sciences (Faculty of Psychology & Educational Sciences), Vrije Universiteit Brussel, Belgium. This reference is a peer-reviewed journal article published within the last two years and is selected for factor analysis. Associated subject areas are: experience design, design psychology, experiential learning, and museum education. Possible cognitive and

emotional factors include: self-motivated inquiry, engagement, experiential learning.

Wurman, R. S., Leifer, L., Sume, D., & Whitehouse, K. (2001). *Information anxiety 2*. Indianapolis, Indiana: Que.

Abstract. A decade after the publication of what has become a cult guidebook to understanding, Richard Saul Wurman, in this expanded and updated volume, gives clarity to confusion with new maps for navigating through a stream of bytes which, [sic] leave us inundated with data but starved for the tools and patterns that give them meaning. In reality there has not been an information explosion, but rather an explosion of non-information, or stuff that simply doesn't inform.

Comments: Wurman, et al. (2001) provide a foundation for the discipline of information architecture and the ability for information design to offer physical and emotional experiences that humans can "decode" as learning. This reference is a book published within the last 10 years and is not selected for factor analysis, due to the age and length of the reference. Associated subject areas are: experience design and design psychology.

Zhang, P., & Li, N. (2005). The importance of affective quality. *Communications of the ACM*, *48*(9), 105-108. doi:10.1145/1081992.1081997

Abstract. Affect, a term that encompasses mood, emotions, and feelings, is a fundamental aspect of human beings, one that influences reflex, perception, cognition, and behavior [5, 6]. Studies in organizational behavior, marketing, and

management have confirmed the strong impact of affect on job satisfaction, decision-making behavior, and consumer shopping behavior. Affective quality is the ability of an object or stimulus to cause changes in one's affect. Limited empirical evidence in human-computer interaction

and information systems research suggests that perceived affective or hedonic quality of an interface has a positive impact on users' perceived usability of the system [8–10]. Essentially, pleasing things work better, are more regularly used, are easier to learn, influence future purchase choices, and produce a more harmonious result. Thus affect and emotion have an important place in design; usability and aesthetics are both instrumental in creating pleasurable electronic products [5]. [sic] [From introduction]

Comments. Zhang and Li's (2005) study finds that "pleasing things work better, are more regularly used [and] are easier to learn" (p. 105). The study suggests "affective quality," defined as "the ability of an object or stimulus to cause changes in one's affect," is a new and useful predictor of a user's "use intention"; that is, affective quality is indicator of whether a user will choose a particular design and affective quality predicts whether users will find a designed system easy to use and/or useful (Ibid, p. 108). Ping Zhang is an associate professor in School of Information Studies at Syracuse University. Na Li is a Ph.D. candidate in the School of Information Studies at Syracuse University. This reference is a peer-reviewed journal article published within the last 5 years and is selected for factor analysis. Associated subject areas are: experience design and design psychology. Possible cognitive and emotional factors include: affective quality,

perceived usefulness, perceived ease of use.

Review of Literature

Factors influencing informal learning experiences in interactive environments are revealed during the secondary coding process, also discussed as factor analysis. Individual factors are clustered into nine larger factor groups and discussed with regard to their relationships to humans, design, and other factor groups. The factor groups are #1 – Affect, #2 – Cognition, #3 – Context, #4 – Engagement, #5 – Experiential Learning, #6 – Interactivity, #7 – Narrative, #8 – Self Concepts, and #9 – Usability. Within each factor group, a table notes specific factors identified in individual references, along with the associated factor group and originating subject area(s), which include: Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Factor Group #1: Affect

Affect can be described as both affect (a response) and affective quality (stimulating a response) (Zhang & Li, 2005, p. 106). Although there are a number of similar terms, Norman (2002) uses the "reasonably neutral term "affect" to include "the concepts of affect, emotion, feelings, mood, motivation, and qualia" (p. 38). Affective quality can be described as "the ability of an object or stimulus to cause changes in one's affect" (Zhang & Li, 2005, p. 105). Notably, "objects, places, and events all have affective quality…[which enters] consciousness as they are affectively interpreted" (Zhang & Li, 2005, p. 106). This study includes the following individual factors in the Affect factor group: *aesthetics*, *affect, affective associations*, *affective quality*, *affinity*, *beauty*, *subjective satisfaction*, and *positive affect* (see Table 3).

Table 3

Affect factor group with individual factors and subject areas

Factors	Subject area(s)	Author	Year
Subjective satisfaction	HII	Alonso-Ríos et al.	2010
Affective associations	HII	Damazio et al.	2009
Affect	HII EL	Hassenzahl & Ullrich	2007
Affinity	HII	Jordan	2010
Beauty	HII	Norman	2002
Positive affect	HII	Norman	2002
Aesthetics	HII	O'Brien & Toms	2010
Affect	HII	O'Brien & Toms	2010
Affective quality	HII	Zhang & Li	2005

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Affect and humans. Emotion is "the conscious experience of affect…[humans] react emotionally to a situation before [they] access it cognitively" (Norman, 2004, p. 11). Subconscious experiences (such as affect) are "the most automatic, or fluent experiences" (Forlizzi & Ford, 2000, p. 421) and are inherent to meaningful human experiences since "positive emotions are critical to learning, curiosity, and creative thought" (Norman, 2004, p. 19). Affect makes humans "smart" (Norman, 2002, p. 39) by helping us judge experiences (Hassenzahl & Ullrich, 2007, p. 432). Affinity is a personal (and judgmental) affective response; humans are "often drawn to a certain design with a natural attraction simply because of its aesthetics and beauty" (Jordan, 2010, p. 6). Affinity can be defined as:

> The emotional connection someone feels for a product or service as driven by these notions of beauty and identity...affinity is about unexplained desire or want. It is often irrational, fluid, and intense. Affinity is the opposite of aversion, and affinity is always positive. (Jordan, 2010, p. 6)

Both positive and negative affect are important, for different reasons. A negative affective response "focuses the mind, leading to better concentration," which is good for dangerous, high-pressure situations (Norman, 2002, p. 38), while "positive affect broadens the thought processes, making us more easily distracted" which is useful for creative problem-solving and low-pressure situations (Norman, 2002, p. 39).

Affect and design. Because "the designed environment is the setting where our experiences take place and is impregnated with emotions" (Damazio et al., 2009, p. 2727), "understanding how and why things evoke emotions is…imperative to designing our environment" (Damazio et al., 2009, p. 2727). Interactions are "inevitably accompanied by affect" (Hassenzahl & Ullrich, 2007, p. 435) and studies have shown affect to be "the single best predictor for the retrospective product evaluation" (Hassenzahl & Ullrich, 2007, p. 434). Hornecker et al. (2007) describe different reflexive affective responses occurring in different situations; they found a "pulling" motion results in positive attitude formation, and a "pushing" motion results in negative attitude formation (p. 336). However, designing for affect and affinities can be "very challenging to include in a typical human-centered design approach" (Jordan, 2010, p. 8). Although recent attention has been given to the idea of experience design as a kind of theater where the participant plays a pre-orchestrated role, emotional experiences are more valuable when they are open-ended; Hennes (2002) notes that "pre-defining the outcome of

experience is the goal of marketing; it is not the open-ended enrichment and pleasure that museums, at their best, can provide" (p. 110). In general, "pleasing things work better, are more regularly used, are easier to learn, influence future purchase choices, and produce a more harmonious result...thus affect and emotion have an important place in design" (Zhang & Li, 2005, p. 105). O'Brien and Toms (2010) describe "a more holistic representation of user engagement that indicates affect should be incorporated into interaction design and measurement" (p. 63).

Affect and other factors. Affect is related to the Cognition, Experiential Learning, Self Concepts and Usability factor groups. Zhang and Li found that "a user's immediate and reflexive affective reaction to [information technology (IT)] has a positive impact on his or her consequent cognition-oriented evaluations" (Zhang & Li, 2005, p. 107). Affect is crucial to learning because "positive affect arouses curiosity, engages creativity, and makes the brain into an effective learning organism" (Norman, 2004, p. 26). In fact, "the act of learning needs to be pleasurable in itself…if the interactor is to remain engaged" (Polaine, 2005, p. 154). Affect is related to self concepts because "the act of choosing and making decisions is intrinsically related to emotions" (Damazio et al., 2009, p. 2730). Affect and usability are inherently linked; "true beauty in a product has to be more than skin deep, more than a façade...good design means that beauty and usability are in balance" (Norman, 2002, p. 42). However, Zhang and Li (2005) note that "empirical evidence is scarce on whether perceived affective quality of a system influences user perceptions of usefulness and ease of use of the system" and that in spite of "recent efforts to bring affect and emotion concepts into user acceptance studies, most

of the existing studies are based on the assumption that human beings are rational and behave based on logical information-based thinking" (p. 106).

Factor Group #2: Cognition

Cognition is defined by Norman (2002) as a neurological response, which "interprets and makes sense of the world"; affect and cognition work together to help humans process information (p. 38). According to Richard Carlson's (1997b) theory of experienced cognition, cognitive experience is the stream of incoming information perceived by humans during consciousness. Cognition can also be described as happening during interactions which "require us to think about what we are doing [and] require attention, cognitive effort, or problem-solving skills [sic]" (Forlizzi & Ford, 2000, p. 421). This study includes the following individual factors in the Cognition factor group: *cognition*, *conceptual coherence*, *concepts*, *focused attention*, *knowability*, *immediate apprehendability*, *internalization*, *inquiry*, *interest*, *mental effort*, *novelty*, *organization of content*, *sub-conscious experience*, and *suspension of disbelief* (see Table 4).

Table 4

Cognition factor group with individual factors and subject areas

Factors	Subject area(s)			Author	Year
Immediate apprehendability	HII	EL	LM	Allen	2004
Conceptual coherence	HII	EL	LM	Allen	2004
Knowability	HII			Alonso-Ríos et al.	2010
Sub-conscious experience	HII			Forlizzi & Ford	2000
Cognition	HII			Forlizzi & Ford	2000
Mental effort	HII	EL		Hassenzahl & Ullrich	2007

Inquiry		EL	LM	Hein	2004
Organization of content		EL	LM	Hennes	2002
Concepts	HII		LM	Lake-Hammond & Waite	2010
Internalization	HII			Van Nimwegen et al.	2006
Focused attention	HII			O'Brien & Toms	2010
Novelty	HII			O'Brien & Toms	2010
Suspension of disbelief	HII			Polaine	2005
Interest	HII	EL		Renninger	2009
Inquiry	HII	EL	LM	Van Moer et al.	2008

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Cognition and humans. According to Forlizzi and Ford (2000), "experience [is the] constant stream that happens during moments of consciousness" (p. 419). Humans become aware of experience through self-talk and narration (Ibid). While "the affective system is judgmental, assigning positive and negative valence to the environment rapidly and efficiently…the cognitive system interprets and makes sense of the world" (Norman, 2002, p. 38). Hennes (2002) contrasts unconscious experience against interrupted experience, the latter being where "memory is formed and growth occurs" (p. 115). Allen suggests "immediate apprehendability," defined as "the quality of a stimulus or larger environments such that people…will understand its purpose, scope, and properties almost immediately and without conscious effort," can reduce cognitive load and make learning possible (Allen, 2004, p. S20). Van Moer et al. (2008) note that encouraging "engaging and assimilated experiences while creating capacities of critical thought and judgment…result[s] in the transformation of visitors' attention into interest" (p. 44).

Hennes (2002) discusses Dewey's concept of inquiry, which begins with a sense of unease or an intellectual conflict and includes the following "steps" in inquiry cycle, which is different for every learner (p. 117-118):

- "interruption, obstruction, breaking the normal flow"
- "observations" and "inference" (a desire to understand the nature of the problem)
- "alternative solutions" (questioning multiple hypothesis)
- "reasoning" (testing and measuring)
- "verification" (resolving unease generated by conflict)

> The process as a whole begins as activity halted by obstruction, moves through a process of thought and concludes again as activity restored. The difference between the activity of the beginning and that of the end is a kind of transformational growth that affects experience in the future. (Ibid, pp. 118-119) (Hennes, 2002, pp. 118-119)

Cognition and design. In order to create a "full cycle of inquiry," museums should "promote reflection and inquiry [in] ways that are not simply 'hands-on'" (Hein, 2004, p. 424). It is important to note "a content-based exhibit need not have a content-based form" (Hennes, 2002, p. 114) and can utilize observation, experimentation, problem solving, pattern recognition. Hennes (2002) suggests "museums can offer experiences in which visitors participate in the formation of purposes driven by their own curiosity and interest" in order to create knowledge, rather than simply transfer it (p. 120). It is critical to "fashion engaging problems out of visitors' own experience, through

which visitors are motivated to draw upon the material resources of the exhibit in a desire for resolution" (Hennes, 2002, p. 116).

Van Moer et al. (2008) note "the challenge for museums is to find ways to formulate exhibitions that start from genuine experiences and lead to inquiry" (p. 50). Exhibition designers should "provide a cognitive map but not…predetermine the route" (Lake-Hammond & Waite, 2010, p. 80). In fact, "exhibits built around problematic situations may provide impetus for visitors to explore content in a way that is most meaningful to them because they take an active role in determining the purpose and the nature of the activity" (Hennes, 2002, p. 117). Not all learners require the same cognitive experience, however; Renninger (2009) describes two phases of interest as it applies to learning:

> In earlier phases of interest development, learners may be most likely to benefit from external supports (e.g., group work, meaningful content) that trigger and help to sustain their interests…In later phases of interest development, learners already have questions about the content and understand that work with the discipline involves open questions that will lead them to challenge their ideas. (p. 112)

Cognition and other factors. Cognition is related to the Affect, Experiential Learning, and Usability factor groups. According to Norman (2004) "emotion and cognition are thoroughly intertwined" (p. 8), since "cognition interprets and understands the world, while emotions allow you to make quick decisions" (p. 11). Renninger (2009) describes interest as "both a cognitive and affective motivational variable" (p. 106). A cognitive experience requires thought and "may offer a learning experience" (Forlizzi &

Ford, 2000, p. 421). Recognizing and designing cognitive tools such as "natural mappings…limiting available controls, [and] standardizing for consistency" help users apprehend, which affects usability (Allen, 2004, p. S21).

Factor Group #3: Context

Although not always mentioned explicitly as an influential factor, many references imply that the context of a learning experience or interaction is critical to understanding its influences or outcome. This study includes explicit references to *context*, *contexts*, and *context of use* as individual factors in the Context factor group (see Table 5) and also discusses indirect references to context.

Table 5

Context factor group with individual factors and subject areas

Factors	Subject area(s)	Author	Year
Context	HII	Alonso-Ríos et al.	2010
Contexts	HII LM	Lake-Hammond & Waite	2010
Context of use	HII	Forlizzi & Ford	2000

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Context and humans. Dewey's notion of experience "has a beginning and an end, and changes the user, and sometimes, the context of the experience as a result" (Forlizzi & Ford, 2000, p. 420). Forlizzi and Ford (2000) note "user-product interactions take place in a context of use, shaped by social, cultural, and organizational behavior patterns" (Ibid). Social contexts are important too, because experiences and "artifacts do not exists outside of social relationships" (Damazio et al., 2009, p. 2733).

Context influences experience evaluation, which is especially dependent on whether the experience is goal (or task) oriented. Hazzenzahl and Ullrich (2007) identify two ways of evaluating experience: experiential (in the moment) and retrospective (after the fact) (p. 431). Experiential measures in the study include mental effort, affect, and spontaneity; retrospective measures are evaluation (judged as positive or negative) and knowledge acquisition (Hassenzahl & Ullrich, 2007, p. 433). Hazzenzahl and Ullrich (2007) also identify two modes of experience: goal mode, where all activity is determined by pursuit of a goal, resulting in more mental effort and learning; and a more spontaneous action mode, where activity determines goals "on the fly" (p. 432). Results in this study show a "higher level of effort and better knowledge acquisition in the goal condition" (Hassenzahl & Ullrich, 2007, p. 433). Interestingly, spontaneity results in positive affect for no-goal interactions, but negative affect for goal mode (Hassenzahl & Ullrich, 2007, p. 436). In other words, a task (goal mode) makes users evaluate experience based on task fulfillment; in this case spontaneity becomes associated with more effort and negative affect. An absence of tasks (action mode) makes users evaluate a product (or experience) separately from learning or mental effort; in this case spontaneity is seen as positive (Hassenzahl & Ullrich, 2007, p. 435).

Context and design. Forlizzi and Ford (2000) discuss context in terms of shifts in the framework of use as important (p. 422). These include:

- Cognitive to subconscious shifts (learned experiences become automatic)
- Subconscious to cognitive (problem encountered; "can also signal that user is creating new knowledge, and that learning is taking place")
- Narrative to cognitive (re-examine established beliefs or processes)

- Subconscious/narrative to cognitive ("move user from the state of experience to having an experience…resulting in learning")
- Subconscious to storytelling (communicate experience)
- Narrative to storytelling (a formal process becomes personal through communication)

Hornecker et al. (2007) suggest museum protocol and organization, such as the implied idea of whether touch is acceptable, affects participant notion of "appropriate behaviors" (p. 340). In order to make museum experiences more accessible, Hein (2004) discusses "taking the museum to the community and the community to the museum" (p. 423). Museums should "formulate exhibitions that lead to inquiry and that guide visitors to apply the results of such inquiry to life situations" (Hein, 2004, p. 424). However, "the ability to relate the immediate outcomes of museum experiences back to life…remains a challenge" (Hein, 2004, p. 424). In terms of message context, museums have "become increasingly open to diverse interpretations of knowledge and more involved in sharing these with a variety of public audiences" (Lake-Hammond & Waite, 2010, p. 81).

Context and other factors. This study notes that context influences all experiences, and therefore is related to all factors, but is of particular concern to creating learning experiences. According to Hein (2004), "all structured, specialized learning environments, whether formal (schools) or informal (museums), need to test their activities constantly against a criterion of their relation for the world outside the specialized setting" (p. 423). Museums "require integrated settings that foster discussion, challenge the learner, make connections to issues of interest to the learner, and provide guidance for application in the world outside the museum" (Ibid, p. 424).

Factor Group #4: Engagement

O'Brien and Toms (2010) note that engagement is a loosely-defined concept, which is problematic because "without a consistent definition of engagement, it is difficult to ascertain that the systems we design and market are, in fact, engaging, or to identify what aspects of the interaction with technology engage or fail to engage users" (p. 50). They define engagement as being comprised of six interrelated factors that culminate in a user's sense of *endurability*: "Endurability was predicted by the other five factors…Aesthetics predicted Perceived Usability, Focused Attention, and Felt Involvement; Novelty predicted Focused Attention and Felt Involvement" (Ibid, p. 62). This study includes the following individual factors in the Engagement factor group: *active prolonged engagement*, *engagement*, *endurability*, *felt involvement*, *flow*, and *playfulness* (see Table 6) and discusses O'Brien and Toms' other factors as they relate to the affect, cognition, and usability factor groups (see Appendix A).

Table 6

Engagement factor group with individual factors and subject areas

Factors	Subject area(s)	Author	Year
Flow	HII EL LM	Allen	2004
Active prolonged engagement APE	HII EL LM	Allen	2004
Engagement	HII EL LM	Birchfield et al.	2008
Engagement	HII	Van Nimwegen et al.	2006
Felt involvement	HII	O'Brien & Toms	2010
Endurability	HII	O'Brien & Toms	2010
Engagement	HII	O'Brien & Toms	2010

Engagement	HII			Polaine	2005
Playfulness	HII			Polaine	2005
Flow	HII			Polaine	2005
Engagement	HII	EL	LM	Van Moer et al.	2008

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Engagement and humans. In order to identify six factors "that encompass the complex interaction between people and technology" which results in engagement, ten subscales of engagement were explored and refined (O'Brien & Toms, 2010, p. 65). The resulting factors of engagement are defined as: Focused Attention, Perceived Usability, Aesthetics, Endurability, Novelty, and Felt Involvement (Ibid, p. 62). Allen (2004) discusses Csikszentmihalyi's idea that ideal learning in a museum is "driven by curiosity and interest then sustained by a flow state" (p. S23). *Flow* can be defined as being "fully involved with mind and body in an intrinsically motivated activity" (Allen, 2004, p. S23). Allen (2004) also discusses "Active Prolonged Engagement (APE)," which includes access to phenomena along with opportunities for deeper cognitive experiences (p. S25). APE results in longer engagement times, elicits "driving questions" and includes physical interactions that vary in pattern and sequence (Allen, 2004, p. S25).

Engagement and design. A key to creating flow is matching challenge to skills, along with well-defined goals and rules (Allen, 2004, p. S23). According to Hennes (2002) "constructing activity with continuity of experience in mind demands that we find a way to provide visitors with a means of constructing the present experience out of what is already meaningful and important to them" (p. 113). This can be problematic in a

museum environment since, "despite an expressed endorsement of visitor-focused experiences, exhibits in these institutions are largely shaped by pre-defined content rather than by experience itself" (Hennes, 2002, p. 110). This is unproductive because "information-based exhibits often create reactions without personal engagement and develop experiences not meaningful enough to capture visitors' attention and open up to further growth" (Van Moer et al., 2008, p. 44).

Engagement and other factors. Engagement is related to the Affect, Cognition, and Self Concepts factor groups. According to O'Brien and Toms (2010) traditional ways of capturing data related to engagement "do not address the users' cognitive or emotional state, both of which are critical to engagement" (p. 52). For learning, "the most important thing is that tools should be developed to stimulate, improve, deepen and smooth the progress of visitors' engagement in the inquiry cycle" (Van Moer et al., 2008, p. 50). The more engaged the participant, the more real learning occurs; knowledge transmission is not the same as being engaged, because "visitors' attention is not transformed into interest" when "transmission of (factual) knowledge is achieved but understanding or engagement of thinking did not happen" (Van Moer et al., 2008, p. 46). Engagement is linked to self concepts because continuity of experience can result in engagement, therefore "constructing activity with continuity of experience in mind demands that we find a way to provide visitors with a means of constructing the present experience out of what is already meaningful and important to them" (Hennes, 2002, p. 113).

Factor Group #5: Experiential Learning

Experiential learning is the idea that humans create meaning from lived

experience. Van Moer et al. suggest "visiting art museums is mainly about viewers making meaning of their experiences through interactions with artefacts [sic]" and note that "phrases such as 'visitor-focused' and 'openended' experiences, 'process of making meaning' and 'experience as a basis for meaningmaking' have roots in constructivist theory, hermeneutic philosophy and social semiotics" (p. 44). This study includes the following individual factors in the Experiential Learning factor group: *continuity of experience*, *diversity of learning modes*, *integrated learning theory*, *learning environments*, *learning styles*, *patterns of inquiry*, and *problematic experience* (see Table 7).

Table 7

Experiential learning factor group with individual factors and subject areas

Factors	Subject area(s)			Author	Year
Diversity of learning modes	HII	EL	LM	Allen	2004
Learning environments		EL	LM	Hein	2004
Problematic experience		EL	LM	Hennes	2002
Patterns of inquiry		EL	LM	Hennes	2002
Continuity of experience		EL	LM	Hennes	2002
Learning styles	HII	EL		Kolb et al.	2001
Integrated learning theory	HII	EL		Kolb et al.	2001
Adaptive learning	HII	EL		Kolb et al.	2001
Experiential learning	HII	EL	LM	Van Moer et al.	2008

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Experiential learning and humans. According to Hennes (2002), "an educative experience is valuable to the extent that it prepares one for broader, richer experiences in the future; it expands possibility"; in fact, "growth itself is both the means and the end" (p. 112). Museums have a mission to offer learning experiences; Hennes (2002) suggests rather than attempting to "impose their own priorities onto visitors, museums can harvest visitors' priorities and offer ways of expanding them into richer purposes and interests" (p. 112). Exploration, physical manipulation, and experimentation help museum visitors learn (Allen, 2004, p. S19). Learning experiences are participatory rather than passive; Hornecker et al. (2007) suggest co-creation of ideas can lead to learning (p. 336). An inquiry cycle can be driven by curiosity (Allen, 2004, p. S20) and sustained by engagement. It is interesting to note that comfort (both psychological and physical) is also a key factor for learning experiences (Allen, 2004, p. S24).

Kolb's Experiential Learning Theory (ELT) suggests learning happens through a process of *grasping* concrete experiences and abstract concepts and *transforming* them through active experimentation or reflective observation (Kolb et al., 2001, p. 228). Human preferences for recognizing and integrating information are known as learning styles, which ELT categorizes as diverging, assimilating, converging, or accommodating (Kolb et al., 2001, pp. 229-231). Recently ELT has intersected with integrated learning theory, which conceives learning as a "spiral" of experiencing, reflecting, thinking, and acting in active response to a learning situation (Kolb et al., 2001, p. 240). The degree to which learners apply styles holistically is known as *adaptive learning*; sophisticated learners apply learning styles in all four areas in an "adaptively flexible" way (Kolb et al., 2001, p. 244).

It is especially notable that problematic experiences may lead to inquiry, and "disequilibrium" can be used as a driver for learning (Allen, 2004, p. S18). In fact, "experiences felt as obstacles for interpretation are extremely suitable to stimulate, deepen and improve visitors' engagement in the inquiry cycle" (Van Moer et al., 2008, p. 43).

Experiential learning and design. Because "visitors vary in their preferences, styles and motivations for learning," multimodal approaches, including multisensory experiences, can be used to apply universal design principles in order to create universally effective learning (Allen, 2004, p. S28). ELT, especially as it applies to adaptive learning, is of particular interest for interactive environments, which are inherently self-directed and can potentially serve a variety of learning styles simultaneously (Kolb et al., 2001). This is easier said than done; "institutions continue to have a difficult time persuading visitors to "learn" while they're having their experiences" (Hennes, 2002, p. 110).

Designers can harness problematic experiences that initiate resolution of cognitive conflict in order to encourage learning; Van Moer et al. (2008) describe Gooding-Brown's "disruptive model" based on problematic experience where multiple (and even conflicting) viewpoints are presented (p. 49). This suggests the participants create their own meaning through a resolution of conflicting opinions: "the basis for the disruptive model is found in the dilemma of authoritative interpretation and multiple voices' interpretation" (Ibid).

Experiential learning and other factors. Experiential learning is obviously connected with the Cognition and Interactivity factor groups, but also with the

Engagement factor group. The "learning process is one of the key elements of engagement" because humans want to become "better" at interactions (Polaine, 2005, p. 154).

Factor Group #6: Interactivity

According to Polaine (2005) "true interactivity is a feedback loop of action-reaction-interaction and involves collaboration or exchange" (p. 151). This study includes the following individual factors in the Interactivity factor group: *access point*, *entry point*, *honeypot effect*, *interactivity*, *physical interactivity*, avoiding *gratuitous interactivity*, *shareability,* and *spontaneity* (see Table 8).

Table 8

Interactivity factor group with individual factors and subject areas

Factors	Subject area(s)			Author	Year
Physical interactivity	HII	EL	LM	Allen	2004
Avoid "gratuitous interactivity"	HII	EL	LM	Allen	2004
Interactivity	HII	EL	LM	Birchfield et al.	2008
Spontaneity	HII	EL		Hassenzahl & Ullrich	2007
Entry point		EL	LM	Hennes	2002
Shareability	HII			Hornecker et al.	2007
Entry point	HII			Hornecker et al.	2007
Access point	HII			Hornecker et al.	2007
Honeypot effect	HII			Hornecker et al.	2007
Interactivity	HII			Polaine	2005

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Interactivity and humans. Sources identified by Birchfield et al. (2008) found "interactive media [and] active participation by visitors has been shown to increase audience attendance and appreciation in museum exhibits" (p. 965). This includes museums, since "exhibits are environments in which complex interactions occur among visitors, objects, environment, and meaning" (Hennes, 2002, p. 109).

Interactivity has a social component as well; *shareability* can be defined as "the extent that a system, interface, or device engages a group of collocated people in shared interactions around the same content (or object)" (Hornecker et al., 2007, p. 329). *Fluidity of sharing* affects "how easily people engaged in shared interactions" (Ibid, p. 336). *Sharable interfaces* mean "all group members can point to and manipulate shared content while simultaneously viewing the interactions and having a shared point of reference" (Ibid, p. 329).

Interactivity and design. According to Lake-Hammond and Waite (2010), "interaction design is particularly significant to exhibition design in the way that it integrates visual communication and the design of material objects" (p. 88). Polaine (2005) notes that "the key to creating engaging interactivity is setting up the correct rules for a playful flow experience" (p. 153). Both "hands-on" and "minds-on" interactivity is important (Allen, 2004, p. S25). Familiar activities can be used as schemas: making a complex machine work, a competition, and watching and waiting, which is a surprisingly social activity (Allen, 2004, p. S22). Some interaction is key, but "exhibits may have an optimal degree of interactivity" (Allen, 2004, p. S25).

Entry and access are important aspects of interaction, because "offering a diversity of entry points enables different levels of engagement, allowing for gradual

adoption and appropriation of a system" (Hornecker et al., 2007, p. 332). Shared interactions cause a visual draw to access points, creating a "honeypot effect" that encourages use (Ibid). According to Hornecker et al. (2007), "entry points invite people and entice them to interact with the system or product" (p. 331) and entry points differ by:

- intrusiveness (attention-drawing)
- richness (amount of information and memory triggers)
- visibility (how perceptible)
- freshness (newness/last use)

Designers should note that "the number and location of access points are important, as too is simultaneous access, which can distribute control in a group" (Hornecker et al., 2007, p. 334). In terms of information experiences, Hennes (2002) suggests creating "entry points into a body of intellectual content" (p. 113), such as:

- analogies (using everyday examples)
- breaking a subject into units that reference participants' prior experience

Interactivity and other factors. Interactivity is related to the Engagement, Experiential Learning, and Narrative factor groups. Polaine (2005) discusses the immersive quality of interactivity as being similar to conventional narratives:

> Conventional narratives attempt to mask the structure of the story (plot, characterisation, dramatic turning points) by using that very structure to create emotional hooks on which to hang our disbelief. When the structure starts to crumble we become aware of the printed page or the fact that we are in the cinema and we start to withdraw from the world of the story.

> This is often because the fine-tuning has gone astray; perhaps a typographic error, an unconvincing visual effect or an infeasible coincidence. When we find an interactive [element or] interface confusing and frustrating (and it is not deliberate) we have a similar experience; we are jettisoned back into real-world emotions and removed from those that we were experiencing in the represented world. (p. 153)

Social aspects of interactions are important to learning because "exhibitions that allow for multiple simultaneous users facilitate family learning" (Allen, 2004, p. S26). Birchfield et al. (2008) note that "constructivist learning [emphasizes] play and exploration in self-guided learning" situations (p. 966). Hands-on learning creates "an increase in motivation and engagement" with "younger visitors more willing to interact" (Ibid, p. 968).

Factor Group #7: Narrative

In terms of exhibition design, narrative can be defined as a structure that "allows the audience to make sense of the objects on display, in relation to one another and their surrounding contexts" (Lake-Hammond & Waite, 2010, p. 91). This study includes the following individual factors in the narrative factor group: *narrative(s)*, *storytelling*, and *subjective experience* (see Table 9).

Table 9

Narrative factor group with individual factors and subject areas

Factors	Subject area(s)	Author	Year
Storytelling	HII EL LM	Allen	2004
Narrative	HII EL LM	Allen	2004

Narrative	HII		Forlizzi & Ford	2000
Storytelling	HII		Forlizzi & Ford	2000
Subjective experience	HII		Forlizzi & Ford	2000
Narratives	HII	LM	Lake-Hammond & Waite	2010
Narrative	HII		Polaine	2005

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Narrative and humans. Narratives are the stories that create meaning from experiences. Forlizzi and Ford (2000) discuss Roger Shank's idea of experience as story, explaining "stories are the vehicles that we use to condense and remember experiences, and to communicate them" (p. 420). Forlizzi and Ford (2000) "use the word *narrative* to represent experiences that have been formalized in the user's head…or in the world" such as product features and *storytelling* to define "the subjective aspects of experience," including context of use and subjective qualities such as emotion, to create "a unique and subjective story" (p. 422). According to Lake-Hammond and Waite (2010):

> A strong narrative enables the visitor to discover the exhibition's complete meaning, rather than viewing it as a series of separate entities. Narrative structure does not need to be explicit or complex. In fact, a subtle narrative tends to be more successful, allowing audiences access to the exhibition message without distracting them with excess information. (p. 92)

Narrative and design. "Personal storytelling" can be an effective learning tool, but needs to be better understood in order to "harness narrative in the service of helping visitors understand exhibits" (Allen, 2004, p. S29). Since "a coherent exhibition narrative

[can] provide the audience with the necessary structure to formulate meaning," it is important to consider narrative from a participant perspective (Lake-Hammond & Waite, 2010, p. 91):

> The audience then is an active participant in the exhibition narrative. The design does not directly tell the audience a story, but implies that one exists, encouraging each individual visitor to interpret the exhibition concept and develop their own understandings. It is important that the designer recognizes that no two visitors will engage in the narrative in the same way. (Ibid, p. 92)

Narrative and other factors. Narrative is related to the Affect and Context factor groups. Forlizzi and Ford (2000) use storytelling to define "the subjective aspects of experience," including context of use and subjective qualities such as emotion, to create "a unique and subjective story" (p. 422).

Factor Group #8: Self Concepts

Self concepts address individual factors concerned with identity and self. The study includes the following individual factors in the Self Concepts factor group: *co-authorship*, *externalization*, *identity and self-dependence* (see Table 9).

Table 10

Self concepts factor group with individual factors and subject areas

Factors	Subject area(s)	Author	Year
Co-authorship	HII	Damazio et al.	2009
Self-dependence	HII	Damazio et al.	2009
Identity	HII	Jordan	2010

Externalization	HII		Van Nimwegen et al.	2006
Identity	HII	EL	Renninger	2009

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Self concepts and humans. Designed experiences are inherently tied to the self, since "identity, like interest, develops through interactions…both interest and identity develop in relation to available experiences and to how learners perceive, understand, and represent these experiences" (Renninger, 2009, p. 106). Damazio et al. (2009) discuss product experiences as co-authored, which creates a sense of self-ownership, since "to appreciate an object is a way of participating in its creation" (p. 2729). According to Jordan (2010):

> A design has the ability to take me back to a place, time, or experience to which I would like to return; it can allow me to be part of a community and can help define me in relation to others in a group; and it can even help me signify who I want to become. (p. 11)

Identifying closely with an experience can create an affinity, which is tied into a sense of self:

> Affinities based on self-image...may be nostalgic (past tense) and relate to who we thought we were or a fondness we have for past experiences. It can also be definitive (present tense) and help us communicate who we are and to which community we belong. And affinity may even be aspirational (future tense) and allow us to project who we want to be and our ideals for our future. (Jordan, 2010, p. 8)

Self concepts and design. Understanding participants and their ideas of self is critical, because "information about interest and identity development could usefully inform the design of tasks, exhibits, and activities; instructional conversations; and expectations for learner participation and achievement" (Renninger, 2009, p. 105). Shared authorship, co-authorship and "design in partnership" can be explained as "designing 'with' as opposed to 'for' people," and includes "collaboration between designers and future users" (Damazio et al., 2009, p. 2729). This participatory and inclusive approach is important for museums because "museums should grow out of life experiences and be used to reflect back on life" (Hein, 2004, p. 420). In order to create personal meaning, "museum experiences, even active ones, still need to be associated with richer, authentic life experiences" (Hein, 2004, p. 423). This implies an important and relatively newly-acknowledged significance for design: "bridging the gap between growing expert knowledge and satisfying an increasing desire for democratic participation in its dissemination can be seen as an important cultural role for design" (Lake-Hammond & Waite, 2010, p. 88).

Self concepts and other factors. Self concepts are related to the Affect factor group because affinity is comprised of an emotional response to beauty and identity, and "identity may be best explored in terms of the self image" (Jordan, 2010, p. 6). The amount of effort and self-investment in an experience can determine affective response, since "the effort exerted in the acquisition of an object is one of the aspects responsible for the feeling of independence that can be generated by the relationship of people with their objects" (Damazio et al., 2009, p. 2730).

Factor Group #9: Usability

Usability can be described as the practice of designing for ease of use, a field rooted in "cognitive sciences—a combination of psychology, computer science, human factors, and engineering" (Norman, 2002, p. 38). *Usability* derives from *userfriendly*, but "no precise definition of usability exists" (Alonso-Ríos et al., 2010, p. 53); many researchers rely on international standards (ISO) definitions (Ibid, p. 54). This study includes the following individual factors in the usability factor group: *usability*, *perceived ease of use*, *perceived usability*, and *perceived usefulness* (see Table 11).

Table 11

Usability factor group with individual factors and subject areas

Factors	Subject area(s)	Author	Year
Usability	HII EL LM	Allen	2004
Usability	HII	Alonso-Ríos et al.	2010
Usability	HII	Norman	2002
Perceived usability	HII	O'Brien & Toms	2010
Usability	HII	Van Nimwegen et al.	2006
Perceived usefulness	HII	Zhang & Li	2005
Perceived ease of use	HII	Zhang & Li	2005

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM).

Usability and humans. User-centered design can be described as an approach that promotes "the creation of objects that, by virtue of their physical forms and location invite certain kinds of use and not others," including the notion of "affordances" or interactions where intended use is natural and apparent (Allen, 2004, p. S21). Alonso-

Ríos et al. (2010) found six areas that pertain to usability: knowability, operability, efficiency, robustness, safety, and subjective satisfaction (p. 60).

Usability and design. According to Forlizzi and Ford (2000), "a successful design will take into consideration all the components in the user-product interaction: user, product, and context of use" (p. 423). It's not enough to simply acknowledge the importance of usability; a more concrete and systematic approach is necessary because "designers need to demystify how we design for user experience and how the products we design achieve specific user experience goals" (Forlizzi & Ford, 2000, p. 419). According to Norman (2002), "human-centered design practices are most essential for tasks or situations that are stressful" since people can tolerate less-user friendly interactions in pleasant situations (p. 40). Usability is critical to museum experiences because a decline in interest and involvement known as *museum fatigue* can set in after about 30 minutes (Allen, 2004, p. S20).

Usability and other factors. Usability is related to the Cognition, Affect, and Context factor groups. Apprehension and usability "reduce the ever-present cognitive load on visitors, freeing them to focus on those aspects of the environment that are rewarding to them and worthy of their attention" (Allen, 2004, p. S24). O'Brien and Toms (2010) suggest "aesthetic judgments are not based solely on users' first impressions; the perceived usability of a system is intertwined with its visual presentation" (p. 63). According to Zhang and Li (2005), "IT designers or IT acquirers should pay attention not only to usefulness (IT suitability for tasks or jobs), and ease of use (the longtime goal of the human computer interaction field), but also to affective quality (the degree to which emotional reactions are evoked)" (p. 108). Context is a

hugely important factor to determine what “usability” means in a given situation, hence “usability depends on context of use” (Alonso-Ríos et al., 2010, p. 60).

Conclusions

Information experiences are changing and require a deeper understanding of human psychology and behavior in order to successfully address the needs of learners in interactive environments. According to Lake-Hammond and Waite (2010), “an exhibition curator is still responsible for the collection and research of the exhibition’s content, but increasingly draws on the interpretive abilities of communication designers to ensure that the exhibition audience can access, interact with, and form their own interpretations of the exhibition's message” (p. 81). The outcome of this study presents a set of factors that museum educators, exhibit designers, information designers, and interaction designers should consider when designing interactive learning environments. The study identifies relevant factors in current literature, clusters them into factor groups, and provides an overview of how each fits into current academic research in a visual study results matrix (Appendix A), showing emerging areas of overlap and omission between fields. Because the study is intended to serve practitioners, a streamlined, high-level overview of the study is also presented in the form of a white paper (Appendix B) that can be used to guide the creation of human-centered interactive learning environments.

According to the references selected for this study, design stakeholders should consider a range of interconnected, influential factors when designing informal learning experiences in interactive learning environments. These factors can be clustered into nine larger factor groups which include: *affect, cognition, context, engagement, experiential learning, interactivity, narrative, self concepts*, and *usability*. The factors identified in this study are interconnected and influence each other to produce experiences. As O'Brien and Toms (2010) suggest, “multiple factors of experience must be examined concurrently

and are related to each other" and the "co-presence of multiple factors during experience will, in future, influence design guidelines" (p. 64). Designers and design stakeholders can consider the influential cognitive and emotional factors presented in order to create successful learning experiences in interactive environments.

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Appendix A: Visual overview of factors (study results matrix)

Author	Year	Subject area(s)			Tag(s)				Factors	Factor group	Pages
Allen	2004	HII	EL	LM	XD	DP	DL	ME	active prolonged engagement	engagement	S25
Allen	2004	HII	EL	LM	XD	DP	DL	ME	avoid “gratuitous interactivity"	interactivity	S30
Allen	2004	HII	EL	LM	XD	DP	DL	ME	conceptual coherence	cognition	S29
Allen	2004	HII	EL	LM	XD	DP	DL	ME	diversity of learning modes	experiential learning	S29
Allen	2004	HII	EL	LM	XD	DP	DL	ME	flow	engagement	S23
Allen	2004	HII	EL	LM	XD	DP	DL	ME	immediate apprehendability	cognition	S29
Allen	2004	HII	EL	LM	XD	DP	DL	ME	narrative	narrative	S28
Allen	2004	HII	EL	LM	XD	DP	DL	ME	physical interactivity	interactivity	S29
Allen	2004	HII	EL	LM	XD	DP	DL	ME	storytelling	narrative	S28
Allen	2004	HII	EL	LM	XD	DP	DL	ME	usability	usability	S20-S24
Alonso-Ríos et al.	2010	HII			XD				context	context	60
Alonso-Ríos et al.	2010	HII			XD				knowability	cognition	56-58
Alonso-Ríos et al.	2010	HII			XD				subjective satisfaction	affect	62-63
Alonso-Ríos et al.	2010	HII			XD				usability	usability	54, 60
Birchfield et al.	2008	HII	EL	LM	XD	DP	DL	ME	engagement	engagement	968
Birchfield et al.	2008	HII	EL	LM	XD	DP	DL	ME	interactivity	interactivity	965, 968
Damazio et al.	2009	HII			XD	DP			affective associations	affect	2731-2733
Damazio et al.	2009	HII			XD	DP			co-authorship	self concepts	2729
Damazio et al.	2009	HII			XD	DP			self-dependence	self concepts	2730
Forlizzi & Ford	2000	HII			XD	DP			cognition	cognition	421-422
Forlizzi & Ford	2000	HII			XD	DP			context of use	context	420
Forlizzi & Ford	2000	HII			XD	DP			narrative	narrative	422
Forlizzi & Ford	2000	HII			XD	DP			storytelling	narrative	422
Forlizzi & Ford	2000	HII			XD	DP			sub-conscious experience	cognition	421
Forlizzi & Ford	2000	HII			XD	DP			subjective experience	narrative	422

Hassenzahl & Ullrich	2007	HII	EL		XD	DP	EL		affect	affect	431-2, 434-6
Hassenzahl & Ullrich	2007	HII	EL		XD	DP	EL		mental effort	cognition	431-2, 434-6
Hassenzahl & Ullrich	2007	HII	EL		XD	DP	EL		spontaneity	interactivity	432, 434-6
Hein	2004		EL	LM			EL	ME	inquiry	cognition	424
Hein	2004		EL	LM			EL	ME	learning environments	experiential learning	423 - 424
Hennes	2002		EL	LM			EL	ME	continuity of experience	experiential learning	111 - 113
Hennes	2002		EL	LM			EL	ME	entry point	interactivity	113
Hennes	2002		EL	LM			EL	ME	organization of content	cognition	113 - 115
Hennes	2002		EL	LM			EL	ME	patterns of inquiry	experiential learning	115
Hennes	2002		EL	LM			EL	ME	problematic experience	experiential learning	111
Hornecker et al.	2007	HII			XD	DP			access point	interactivity	329 - 331, 333
Hornecker et al.	2007	HII			XD	DP			entry point	interactivity	329 - 333
Hornecker et al.	2007	HII			XD	DP			honeypot effect	interactivity	332
Hornecker et al.	2007	HII			XD	DP			shareability	interactivity	329, 336 - 337
Jordan	2010	HII			XD	DP			affinity	affect	6
Jordan	2010	HII			XD	DP			identity	self concepts	8
Kolb et al.	2001	HII	EL		XD		EL		adaptive learning	experiential learning	244
Kolb et al.	2001	HII	EL		XD		EL		integrated learning theory	experiential learning	240
Kolb et al.	2001	HII	EL		XD		EL		learning styles	experiential learning	229 - 331
Lake-Hammond & Waite	2010	HII		LM	XD	DP		ME	concepts	cognition	80
Lake-Hammond & Waite	2010	HII		LM	XD	DP		ME	contexts	context	91
Lake-Hammond & Waite	2010	HII		LM	XD	DP		ME	narratives	narrative	91 - 92
Norman	2002	HII			XD	DP			beauty	affect	38, 42
Norman	2002	HII			XD	DP			positive affect	affect	38

Norman	2002	HII			XD	DP			usability	usability	38, 42
O'Brien & Toms	2010	HII			XD	DP			aesthetics	affect	57, 63
O'Brien & Toms	2010	HII			XD	DP			affect	affect	63
O'Brien & Toms	2010	HII			XD	DP			endurability	engagement	57, 59, 63
O'Brien & Toms	2010	HII			XD	DP			engagement	engagement	50 - 52
O'Brien & Toms	2010	HII			XD	DP			felt involvement	engagement	58, 63
O'Brien & Toms	2010	HII			XD	DP			focused attention	cognition	56
O'Brien & Toms	2010	HII			XD	DP			novelty	cognition	58
O'Brien & Toms	2010	HII			XD	DP			perceived usability	usability	56, 63
Polaine	2005	HII			XD	DP			engagement	engagement	154
Polaine	2005	HII			XD	DP			flow	engagement	153
Polaine	2005	HII			XD	DP			interactivity	interactivity	153
Polaine	2005	HII			XD	DP			narrative	narrative	153
Polaine	2005	HII			XD	DP			playfulness	engagement	153
Polaine	2005	HII			XD	DP			suspension of disbelief	cognition	152
Renninger	2009	HII	EL			DP	EL		identity	self concepts	106, 109
Renninger	2009	HII	EL			DP	EL		interest	cognition	106, 107
Van Moer et al.	2008	HII	EL	LM	XD	DP	EL	ME	engagement	engagement	43-44, 50
Van Moer et al.	2008	HII	EL	LM	XD	DP	EL	ME	experiential learning	experiential learning	43-44
Van Moer et al.	2008	HII	EL	LM	XD	DP	EL	ME	inquiry	cognition	44, 50
Van Nimwegen et al.	2006	HII			XD	DP			engagement	engagement	790
Van Nimwegen et al.	2006	HII			XD	DP			externalization	self concepts	785, 790
Van Nimwegen et al.	2006	HII			XD	DP			internalization	cognition	790
Van Nimwegen et al.	2006	HII			XD	DP			usability	usability	790
Zhang & Li	2005	HII			XD	DP			affective quality	affect	105 - 108
Zhang & Li	2005	HII			XD	DP			perceived ease of use	usability	108
Zhang & Li	2005	HII			XD	DP			perceived usefulness	usability	108

Note. Subject areas are Human Interactions with Information (HII), Experiential Learning (EL), and Learning in Museums (LM). Tag areas Experience Design (XD), Design Psychology (DS), Experiential Learning (EL), and Museum Education (ME).

Appendix B: White paper report of study and factors

See self-contained PDF white paper on following pages.

learning by design

Cognitive and Emotional Factors Influencing Informal Learning Experiences in Interactive Environments

Presented to the Interdisciplinary Studies Program
Applied Information Management and the
Graduate School of the University of Oregon
in partial fulfillment of the requirement for the
degree of Master of Science

Nicole Leaper
Senior Communication Designer
Bullseye Gallery / Bullseye Glass Co.

executive summary

This white paper presents an overview of a study synthesizing current literature in educational and design psychology, information design, human-computer interaction, and museum studies in order to identify cognitive and emotional factors that influence learning (Leaper, 2011). The study presents a set of cognitive and emotional factors that museum educators, exhibit designers, information designers, and interaction designers (along with other key design stakeholders) should consider when designing informal learning experiences in interactive environments.

Information experiences are changing and require a deeper understanding of human psychology and behavior in order to successfully address the needs of learners in interactive environments. According to Lake-Hammond and Waite (2010), "an exhibition curator is still responsible for the collection and research of the exhibition's content, but increasingly draws on the interpretive abilities of communication designers to ensure that the exhibition audience can access, interact with, and form their own interpretations of the exhibition's message" (p. 81). This white paper presents a set of factors that museum educators, exhibit designers, information designers, and interaction designers should consider when designing interactive learning environments. The white paper is based on a study that identifies relevant factors in current literature, clusters them into factor groups, and provides an overview of how each fits into current academic research in a visual study results matrix (Leaper, 2011, Appendix A), showing emerging areas of overlap and omission between fields. This white paper offers a streamlined, high-level overview of the study which can be used to guide the creation of human-centered interactive learning environments.

According to the references selected for the study, design stakeholders should consider a range of interconnected, influential factors when designing informal learning experiences in interactive learning environments. These factors can be clustered into nine larger factor groups which include: affect, cognition, context, engagement, experiential learning, interactivity, narrative, self concepts, and usability. The factors identified in the study are interconnected and influence each other to produce experiences. As O'Brien and Toms (2010) suggest, "multiple factors of experience must be examined concurrently and are related to each other" and the "co-presence of multiple factors during experience will, in future, influence design guidelines" (p. 64). Designers and design stakeholders can consider the influential cognitive and emotional factors presented in order to create successful learning experiences in interactive environments.

Stakeholders should consider a range of interconnected, influential factors when designing informal learning experiences in interactive learning environments. These factors can be clustered into nine larger factor groups which include: affect, cognition, context, engagement, experiential learning, interactivity, narrative, self concepts, and usability.

affect

Affect can be described as both affect (a response) and affective quality (stimulating a response) (Zhang & Li, 2005, p. 106). Although there are a number of similar terms, Norman (2002) uses the "reasonably neutral term "affect" to include "the concepts of affect, emotion, feelings, mood, motivation, and qualia" (p. 38). Affective quality can be described as "the ability of an object or stimulus to cause changes in one's affect" (Zhang & Li, 2005, p. 105). Notably, "objects, places, and events all have affective quality…[which enters] consciousness as they are affectively interpreted" (Zhang & Li, 2005, p. 106). This study includes the following individual factors in the Affect factor group: *aesthetics, affect, affective associations, affective quality, affinity, beauty, subjective satisfaction*, and *positive affect*.

Affect and humans. Emotion is "the conscious experience of affect…[humans] react emotionally to a situation before [they] access it cognitively" (Norman, 2004, p. 11). Subconscious experiences (such as affect) are "the most automatic, or fluent experiences" (Forlizzi & Ford, 2000, p. 421) and are inherent to meaningful human experiences since "positive emotions are critical to learning, curiosity, and creative thought" (Norman, 2004, p. 19). Affect makes humans "smart" (Norman, 2002, p. 39) by helping us judge experiences (Hassenzahl & Ullrich, 2007, p. 432). Affinity is a personal (and judgmental) affective response; humans are "often drawn to a certain design with a natural attraction simply because of its aesthetics and beauty" (Jordan, 2010, p. 6). Affinity can be defined as:

> The emotional connection someone feels for a product or service as driven by these notions of beauty and identity...affinity is about unexplained desire or want. It is often irrational, fluid, and intense. Affinity is the opposite of aversion, and affinity is always positive. (Jordan, 2010, p. 6)

Both positive and negative affect are important, for different reasons. A negative affective response "focuses the mind, leading to better concentration," which is good for dangerous, high-pressure situations (Norman, 2002, p. 38), while "positive affect broadens the thought processes, making us more easily distracted" which is useful for creative problem-solving and low-pressure situations (Norman, 2002, p. 39).

Affect and design. Because "the designed environment is the setting where our experiences take place and is impregnated with emotions" (Damazio et al., 2009, p. 2727), "understanding how and why things evoke emotions is…imperative to designing our environment" (Damazio et al., 2009, p. 2727). Interactions are "inevitably accompanied by affect" (Hassenzahl & Ullrich, 2007, p. 435) and studies have shown affect to be "the single best predictor for the retrospective product evaluation" (Hassenzahl & Ullrich, 2007, p. 434). Hornecker et al. (2007) describe different reflexive affective responses occurring in different situations; they found a "pulling" motion results in positive attitude formation, and a "pushing" motion results in negative attitude formation (p. 336). However, designing for affect and affinities can be "very challenging to include in a typical human-centered design approach" (Jordan, 2010, p. 8). Although recent attention has been given to the idea of experience design as a kind of theater where the participant plays a pre-orchestrated role, emotional experiences are more valuable when they are open-ended; Hennes (2002) notes that "pre-defining the outcome of experience is the goal of marketing; it is not the open-ended enrichment and pleasure that museums, at their best, can provide" (p. 110). In general, "pleasing things work better, are more regularly used, are easier to learn, influence future purchase choices, and produce a more harmonious result...thus affect and emotion have an important place in design" (Zhang & Li, 2005, p. 105). O'Brien and Toms (2010) describe "a more holistic representation of user engagement that indicates affect should be incorporated into interaction design and measurement" (p. 63).

Both positive and negative affect are important, for different reasons.

Affect and other factors. Affect is related to the Cognition, Experiential Learning, Self Concepts and Usability factor groups. Zhang and Li found that "a user's immediate and reflexive affective reaction to [information technology (IT)] has a positive impact on his or her consequent cognition-oriented evaluations" (Zhang & Li, 2005, p. 107). Affect is crucial to learning because "positive affect arouses curiosity, engages creativity, and makes the brain into an effective learning organism" (Norman, 2004, p. 26). In fact, "the act of learning needs to be pleasurable in itself…if the interactor is to remain engaged" (Polaine, 2005, p. 154). Affect is

affect (continued)

related to self concepts because "the act of choosing and making decisions is intrinsically related to emotions" (Damazio et al., 2009, p. 2730). Affect and usability are inherently linked; "true beauty in a product has to be more than skin deep, more than a façade...good design means that beauty and usability are in balance" (Norman, 2002, p. 42). However, Zhang and Li (2005) note that "empirical evidence is scarce on whether perceived affective quality of a system influences user perceptions of usefulness and ease of use of the system" and that in spite of "recent efforts to bring affect and emotion concepts into user acceptance studies, most of the existing studies are based on the assumption that human beings are rational and behave based on logical information-based thinking" (p. 106).

Affect and usability are inherently linked; "true beauty in a product has to be more than skin deep, more than a façade...good design means that beauty and usability are in balance". (Norman, 2002, p. 42)

cognition

Cognition is defined by Norman (2002) as a neurological response, which "interprets and makes sense of the world"; affect and cognition work together to help humans process information (p. 38). According to Richard Carlson's (1997b) theory of experienced cognition, cognitive experience is the stream of incoming information perceived by humans during consciousness. Cognition can also be described as happening during interactions which "require us to think about what we are doing [and] require attention, cognitive effort, or problem-solving skills [sic]" (Forlizzi & Ford, 2000, p. 421). This study includes the following individual factors in the Cognition factor group: *cognition, conceptual coherence, concepts, focused attention, knowability, immediate apprehendability, internalization, inquiry, interest, mental effort, novelty, organization of content, sub-conscious experience*, and *suspension of disbelief*.

Cognition and humans. According to Forlizzi and Ford (2000), "experience [is the] constant stream that happens during moments of consciousness" (p. 419). Humans become aware of experience through self-talk and narration (Ibid). While "the affective system is judgmental, assigning positive and negative valence to the environment rapidly and efficiently…the cognitive system interprets and makes sense of the world" (Norman, 2002, p. 38). Hennes (2002) contrasts unconscious experience against interrupted experience, the latter being where "memory is formed and growth occurs" (p. 115). Allen suggests "immediate apprehendability," defined as "the quality of a stimulus or larger environments such that people…will understand its purpose, scope, and properties almost immediately and without conscious effort," can reduce cognitive load and make learning possible (Allen, 2004, p. S20). Van Moer et al. (2008) note that encouraging "engaging and assimilated experiences while creating capacities of critical thought and judgment…result[s] in the transformation of visitors' attention into interest" (p. 44). Hennes (2002) discusses Dewey's concept of inquiry, which begins with a sense of unease or an intellectual conflict and includes the following "steps" in inquiry cycle, which is different for every learner (p. 117-118):

- "interruption, obstruction, breaking the normal flow"
- "observations" and "inference" (a desire to understand the nature of the problem)
- "alternative solutions" (questioning multiple hypothesis)
- "reasoning" (testing and measuring)
- "verification" (resolving unease generated by conflict)

The process as a whole begins as activity halted by obstruction, moves through a process of thought and concludes again as activity restored. The difference between the activity of the beginning and that of the end is a kind of transformational growth that affects experience in the future. (Hennes, 2002, pp. 118-119)

Cognition and design. In order to create a "full cycle of inquiry," museums should "promote reflection and inquiry [in] ways that are not simply 'hands-on'" (Hein, 2004, p. 424). It is important to note "a content-based exhibit need not have a content-based form" (Hennes, 2002, p. 114) and can utilize observation, experimentation, problem solving, pattern recognition. Hennes (2002) suggests "museums can offer experiences in which visitors participate in the formation of purposes driven by their own curiosity and interest" in order to create knowledge, rather than simply transfer it (p. 120). It is critical to "fashion engaging problems out of visitors' own experience, through which visitors are motivated to draw upon the material resources of the exhibit in a desire for resolution" (Hennes, 2002, p. 116).

Cognition "interprets and makes sense of the world"; affect and cognition work together to help humans process information. (Norman, 2002, p. 38)

Van Moer et al. (2008) note "the challenge for museums is to find ways to formulate exhibitions that start from genuine experiences and lead to inquiry" (p. 50). Exhibition designers should "provide a cognitive map but not…predetermine the route" (Lake-Hammond & Waite, 2010, p. 80). In fact, "exhibits built around problematic situations may provide impetus for visitors to explore content in a way that is most meaningful to them because they take an active role in determining the purpose and the nature of the activity" (Hennes, 2002, p. 117). Not all learners require the same cognitive experience, however; Renninger (2009) describes two phases of interest as it applies to learning:

cognition (continued)

> In earlier phases of interest development, learners may be most likely to benefit from external supports (e.g., group work, meaningful content) that trigger and help to sustain their interests… In later phases of interest development, learners already have questions about the content and understand that work with the discipline involves open questions that will lead them to challenge their ideas. (p. 112)

Cognition and other factors. Cognition is related to the Affect, Experiential Learning, and Usability factor groups. According to Norman (2004) "emotion and cognition are thoroughly intertwined" (p. 8), since "cognition interprets and understands the world, while emotions allow you to make quick decisions" (p. 11). Renninger (2009) describes interest as "both a cognitive and affective motivational variable" (p. 106). A cognitive experience requires thought and "may offer a learning experience" (Forlizzi & Ford, 2000, p. 421). Recognizing and designing cognitive tools such as "natural mappings…limiting available controls, [and] standardizing for consistency" help users apprehend, which affects usability (Allen, 2004, p. S21).

The difference between the activity of the beginning and that of the end is a kind of transformational growth that affects experience in the future.

(Hennes, 2002, pp. 118-119)

context

Although not always mentioned explicitly as an influential factor, many references imply that the context of a learning experience or interaction is critical to understanding its influences or outcome. This study includes explicit references to *context, contexts*, and *context of use* as individual factors in the Context factor group and also discusses indirect references to context.

Context and humans. Dewey's notion of experience "has a beginning and an end, and changes the user, and sometimes, the context of the experience as a result" (Forlizzi & Ford, 2000, p. 420). Forlizzi and Ford (2000) note "user-product interactions take place in a context of use, shaped by social, cultural, and organizational behavior patterns" (Ibid). Social contexts are important too, because experiences and "artifacts do not exists outside of social relationships" (Damazio et al., 2009, p. 2733).

Context influences experience evaluation, which is especially dependent on whether the experience is goal (or task) oriented. Hazzenzahl and Ullrich (2007) identify two ways of evaluating experience: experiential (in the moment) and retrospective (after the fact) (p. 431). Experiential measures in the study include mental effort, affect, and spontaneity; retrospective measures are evaluation (judged as positive or negative) and knowledge acquisition (Hassenzahl & Ullrich, 2007, p. 433). Hazzenzahl and Ullrich (2007) also identify two modes of experience: goal mode, where all activity is determined by pursuit of a goal, resulting in more mental effort and learning; and a more spontaneous action mode, where activity determines goals "on the fly" (p. 432). Results in this study show a "higher level of effort and better knowledge acquisition in the goal condition" (Hassenzahl & Ullrich, 2007, p. 433). Interestingly, spontaneity results in positive affect for no-goal interactions, but negative affect for goal mode (Hassenzahl & Ullrich, 2007, p. 436). In other words, a task (goal mode) makes users evaluate experience based on task fulfillment; in this case spontaneity becomes associated with more effort and negative affect. An absence of tasks (action mode) makes users evaluate a product (or experience) separately from learning or mental effort; in this case spontaneity is seen as positive (Hassenzahl & Ullrich, 2007, p. 435).

Context and design. Forlizzi and Ford (2000) discuss context in terms of shifts in the framework of use as important (p. 422). These include:

- Cognitive to subconscious shifts (learned experiences become automatic)
- Subconscious to cognitive (problem encountered; "can also signal that user is creating new knowledge, and that learning is taking place")
- Narrative to cognitive (re-examine established beliefs or processes)
- Subconscious/narrative to cognitive ("move user from the state of experience to having an experience…resulting in learning")
- Subconscious to storytelling (communicate experience)
- Narrative to storytelling (a formal process becomes personal through communication)

Hornecker et al. (2007) suggest museum protocol and organization, such as the implied idea of whether touch is acceptable, affects participant notion of "appropriate behaviors" (p. 340). In order to make museum experiences more accessible, Hein (2004) discusses "taking the museum to the community and the community to the museum" (p. 423). Museums should "formulate exhibitions that lead to inquiry and that guide visitors to apply the results of such inquiry to life situations" (Hein, 2004, p. 424). However, "the ability to relate the immediate outcomes of museum experiences back to life…remains a challenge" (Hein, 2004, p. 424). In terms of message context, museums have "become increasingly open to diverse interpretations of knowledge and more involved in sharing these with a variety of public audiences" (Lake-Hammond & Waite, 2010, p. 81).

Context influences all experiences.

Context and other factors. This study notes that context influences all experiences, and therefore is related to all factors, but is of particular concern to creating learning experiences. According to Hein (2004), "all structured, specialized learning environments, whether formal (schools) or informal (museums), need to test their activities constantly against a criterion of their relation for the world outside the specialized setting" (p. 423). Museums "require integrated settings that foster discussion, challenge the learner, make connections to issues of interest to the learner, and provide guidance for application in the world outside the museum" (Ibid, p. 424).

engagement

O'Brien and Toms (2010) note that engagement is a loosely-defined concept, which is problematic because "without a consistent definition of engagement, it is difficult to ascertain that the systems we design and market are, in fact, engaging, or to identify what aspects of the interaction with technology engage or fail to engage users" (p. 50). They define engagement as being comprised of six interrelated factors that culminate in a user's sense of endurability: "Endurability was predicted by the other five factors…Aesthetics predicted Perceived Usability, Focused Attention, and Felt Involvement; Novelty predicted Focused Attention and Felt Involvement" (Ibid, p. 62). This study includes the following individual factors in the Engagement factor group: *active prolonged engagement, engagement, endurability, felt involvement, flow*, and *playfulness* and discusses O'Brien and Toms' other factors as they relate to the affect, cognition, and usability factor groups (Leaper, 2011, Appendix A).

Engagement and humans. In order to identify six factors "that encompass the complex interaction between people and technology" which results in engagement, ten subscales of engagement were explored and refined (O'Brien & Toms, 2010, p. 65). The resulting factors of engagement are defined as: Focused Attention, Perceived Usability, Aesthetics, Endurability, Novelty, and Felt Involvement (Ibid, p. 62). Allen (2004) discusses Csikszentmihalyi's idea that ideal learning in a museum is "driven by curiosity and interest then sustained by a flow state" (p. S23). Flow can be defined as being "fully involved with mind and body in an intrinsically motivated activity" (Allen, 2004, p. S23). Allen (2004) also discusses "Active Prolonged Engagement (APE)," which includes access to phenomena along with opportunities for deeper cognitive experiences (p. S25). APE results in longer engagement times, elicits "driving questions" and includes physical interactions that vary in pattern and sequence (Allen, 2004, p. S25).

Engagement and design. A key to creating flow is matching challenge to skills, along with well-defined goals and rules (Allen, 2004, p. S23). According to Hennes (2002) "constructing activity with continuity of experience in mind demands that we find a way to provide visitors with a means of constructing the present experience out of what is already meaningful and important to them" (p. 113). This can be problematic in a museum environment since, "despite an expressed endorsement of visitor-focused experiences, exhibits in these institutions are largely shaped by pre-defined content rather than by experience itself" (Hennes, 2002, p. 110). This is unproductive because "information-based exhibits often create reactions without personal engagement and develop experiences not meaningful enough to capture visitors' attention and open up to further growth" (Van Moer et al., 2008, p. 44).

The more engaged the participant, the more real learning occurs.

Engagement and other factors. Engagement is related to the Affect, Cognition, and Self Concepts factor groups. According to O'Brien and Toms (2010) traditional ways of capturing data related to engagement "do not address the users' cognitive or emotional state, both of which are critical to engagement" (p. 52). For learning, "the most important thing is that tools should be developed to stimulate, improve, deepen and smooth the progress of visitors' engagement in the inquiry cycle" (Van Moer et al., 2008, p. 50). The more engaged the participant, the more real learning occurs; knowledge transmission is not the same as being engaged, because "visitors' attention is not transformed into interest" when "transmission of (factual) knowledge is achieved but understanding or engagement of thinking did not happen" (Van Moer et al., 2008, p. 46). Engagement is linked to self concepts because continuity of experience can result in engagement, therefore "constructing activity with continuity of experience in mind demands that we find a way to provide visitors with a means of constructing the present experience out of what is already meaningful and important to them" (Hennes, 2002, p. 113).

experiential learning

Experiential learning is the idea that humans create meaning from lived experience. Van Moer et al. suggest "visiting art museums is mainly about viewers making meaning of their experiences through interactions with artefacts [sic]" and note that "phrases such as 'visitor-focused' and 'openended' experiences, 'process of making meaning' and 'experience as a basis for meaningmaking' have roots in constructivist theory, hermeneutic philosophy and social semiotics" (p. 44). This study includes the following individual factors in the Experiential Learning factor group: *continuity of experience, diversity of learning modes, integrated learning theory, learning environments, learning styles, patterns of inquiry*, and *problematic experience*.

Experiential learning and humans. According to Hennes (2002), "an educative experience is valuable to the extent that it prepares one for broader, richer experiences in the future; it expands possibility"; in fact, "growth itself is both the means and the end" (p. 112). Museums have a mission to offer learning experiences; Hennes (2002) suggests rather than attempting to "impose their own priorities onto visitors, museums can harvest visitors' priorities and offer ways of expanding them into richer purposes and interests" (p. 112). Exploration, physical manipulation, and experimentation help museum visitors learn (Allen, 2004, p. S19). Learning experiences are participatory rather than passive; Hornecker et al. (2007) suggest co-creation of ideas can lead to learning (p. 336). An inquiry cycle can be driven by curiosity (Allen, 2004, p. S20) and sustained by engagement. It is interesting to note that comfort (both psychological and physical) is also a key factor for learning experiences (Allen, 2004, p. S24).

Kolb's Experiential Learning Theory (ELT) suggests learning happens through a process of grasping concrete experiences and abstract concepts and transforming them through active experimentation or reflective observation (Kolb et al., 2001, p. 228). Human preferences for recognizing and integrating information are known as learning styles, which ELT categorizes as diverging, assimilating, converging, or accommodating (Kolb et al., 2001, pp. 229-231). Recently ELT has intersected with integrated learning theory, which conceives learning as a "spiral" of experiencing, reflecting, thinking, and acting in active response to a learning situation (Kolb et al., 2001, p. 240). The degree to which learners apply styles holistically is known as adaptive learning; sophisticated learners apply learning styles in all four areas in an "adaptively flexible" way (Kolb et al., 2001, p. 244).

It is especially notable that problematic experiences may lead to inquiry, and "disequilibrium" can be used as a driver for learning (Allen, 2004, p. S18). In fact, "experiences felt as obstacles for interpretation are extremely suitable to stimulate, deepen and improve visitors' engagement in the inquiry cycle" (Van Moer et al., 2008, p. 43).

Experiential learning and design. Because "visitors vary in their preferences, styles and motivations for learning," multimodal approaches, including multisensory experiences, can be used to apply universal design principles in order to create universally effective learning (Allen, 2004, p. S28). ELT, especially as it applies to adaptive learning, is of particular interest for interactive environments, which are inherently self-directed and can potentially serve a variety of learning styles simultaneously (Kolb et al., 2001). This is easier said than done; "institutions continue to have a difficult time persuading visitors to "learn" while they're having their experiences" (Hennes, 2002, p. 110).

Problematic experiences which initiate resolution of cognitive conflict can encourage learning

Designers can harness problematic experiences which initiate resolution of cognitive conflict in order to encourage learning; Van Moer et al. (2008) describe Gooding-Brown's "disruptive model" based on problematic experience where multiple (and even conflicting) viewpoints are presented (p. 49). This suggests the participants create their own meaning through a resolution of conflicting opinions: "the basis for the disruptive model is found in the dilemma of authoritative interpretation and multiple voices' interpretation" (Ibid).

Experiential learning and other factors. Experiential learning is obviously connected with the Cognition and Interactivity factor groups, but also with the Engagement factor group. The "learning process is one of the key elements of engagement" because humans want to become "better" at interactions (Polaine, 2005, p. 154).

interactivity

According to Polaine (2005) "true interactivity is a feedback loop of action-reaction-interaction and involves collaboration or exchange" (p. 151). This study includes the following individual factors in the Interactivity factor group: *access point, entry point, honeypot effect, interactivity, physical interactivity, avoiding gratuitous interactivity, shareability*, and *spontaneity.*

Interactivity and humans. Sources identified by Birchfield et al. (2008) found "interactive media [and] active participation by visitors has been shown to increase audience attendance and appreciation in museum exhibits" (p. 965). This includes museums, since "exhibits are environments in which complex interactions occur among visitors, objects, environment, and meaning" (Hennes, 2002, p. 109).

Interactivity has a social component as well; shareability can be defined as "the extent that a system, interface, or device engages a group of collocated people in shared interactions around the same content (or object)" (Hornecker et al., 2007, p. 329). Fluidity of sharing affects "how easily people engaged in shared interactions" (Ibid, p. 336). Sharable interfaces mean "all group members can point to and manipulate shared content while simultaneously viewing the interactions and having a shared point of reference" (Hornecker et al., 2007, p. 329).

Interactivity and design. According to Lake-Hammond and Waite (2010), "interaction design is particularly significant to exhibition design in the way that it integrates visual communication and the design of material objects" (p. 88). Polaine (2005) notes that "the key to creating engaging interactivity is setting up the correct rules for a playful flow experience" (p. 153). Both "hands-on" and "minds-on" interactivity is important (Allen, 2004, p. S25). Familiar activities can be used as schemas: making a complex machine work, a competition, and watching and waiting, which is a surprisingly social activity (Allen, 2004, p. S22). Some interaction is key, but "exhibits may have an optimal degree of interactivity" (Allen, 2004, p. S25).

Entry and access are important aspects of interaction, because "offering a diversity of entry points enables different levels of engagement, allowing for gradual adoption and appropriation of a system" (Hornecker et al., 2007, p. 332). Shared interactions cause a visual draw to access points, creating a "honeypot effect" that encourages use (Ibid). According to Hornecker et al. (2007), "entry points invite people and entice them to interact with the system or product" (p. 331) and entry points differ by:

- intrusiveness (attention-drawing)
- richness (amount of information and memory triggers)
- visibility (how perceptible)
- freshness (newness/last use)

Designers should note that "the number and location of access points are important, as too is simultaneous access, which can distribute control in a group" (Hornecker et al., 2007, p. 334). In terms of information experiences, Hennes (2002) suggests creating "entry points into a body of intellectual content" (p. 113), such as:

- analogies (using everyday examples)
- breaking a subject into units that reference participants' prior experience

Interactivity and other factors. Interactivity is related to the Engagement, Experiential Learning, and Narrative factor groups. Polaine (2005) discusses the immersive quality of interactivity as being similar to conventional narratives:

> Conventional narratives attempt to mask the structure of the story (plot, characterisation, dramatic turning points) by using that very structure to create emotional hooks on which to hang our disbelief. When the structure starts to crumble we become aware of the printed page or the fact that we are in the cinema and we start to withdraw from the world of the story. This is often because the fine-tuning has gone astray; perhaps a typographic error, an unconvincing visual effect or an infeasible coincidence. When we find an interactive [element or] interface confusing and frustrating (and it is not deliberate) we have a similar experience; we are jettisoned back into real-world emotions and removed from those that we were experiencing in the represented world. (p. 153)

Social aspects of interactions are important to learning because "exhibitions that allow for multiple simultaneous users facilitate family learning" (Allen, 2004, p. S26). Birchfield et al. (2008) note that "constructivist learning [emphasizes] play and exploration in self-guided learning" situations (p. 966). Hands-on learning creates "an increase in motivation and engagement" with "younger visitors more willing to interact" (Ibid, p. 968).

narrative

In terms of exhibition design, narrative can be defined as a structure that "allows the audience to make sense of the objects on display, in relation to one another and their surrounding contexts" (Lake-Hammond & Waite, 2010, p. 91). This study includes the following individual factors in the narrative factor group: *narrative(s), storytelling*, and *subjective experience*.

Narrative and humans. Narratives are the stories that create meaning from experiences. Forlizzi and Ford (2000) discuss Roger Shank's idea of experience as story, explaining "stories are the vehicles that we use to condense and remember experiences, and to communicate them" (p. 420). Forlizzi and Ford (2000) "use the word narrative to represent experiences that have been formalized in the user's head…or in the world" such as product features and storytelling to define "the subjective aspects of experience," including context of use and subjective qualities such as emotion, to create "a unique and subjective story" (p. 422). According to Lake-Hammond and Waite (2010):

> A strong narrative enables the visitor to discover the exhibition's complete meaning, rather than viewing it as a series of separate entities. Narrative structure does not need to be explicit or complex. In fact, a subtle narrative tends to be more successful, allowing audiences access to the exhibition message without distracting them with excess information. (p. 92)

Narratives are the stories that create meaning from experience.

Narrative and design. "Personal storytelling" can be an effective learning tool, but needs to be better understood in order to "harness narrative in the service of helping visitors understand exhibits" (Allen, 2004, p. S29). Since "a coherent exhibition narrative [can] provide the audience with the necessary structure to formulate meaning," it is important to consider narrative from a participant perspective (Lake-Hammond & Waite, 2010, p. 91):

> The audience then is an active participant in the exhibition narrative. The design does not directly tell the audience a story, but implies that one exists, encouraging each individual visitor to interpret the exhibition concept and develop their own understandings. It is important that the designer recognizes that no two visitors will engage in the narrative in the same way. (Ibid, p. 92)

Narrative and other factors. Narrative is related to the Affect and Context factor groups. Forlizzi and Ford (2000) use storytelling to define "the subjective aspects of experience," including context of use and subjective qualities such as emotion, to create "a unique and subjective story" (p. 422).

self concepts

Self concepts address individual factors concerned with identity and self. The study includes the following individual factors in the Self Concepts factor group: co-authorship, externalization, identity and self-dependence.

Self concepts and humans. Designed experiences are inherently tied to the self, since "identity, like interest, develops through interactions…both interest and identity develop in relation to available experiences and to how learners perceive, understand, and represent these experiences" (Renninger, 2009, p. 106). Damazio et al. (2009) discuss product experiences as co-authored, which creates a sense of self-ownership, since "to appreciate an object is a way of participating in its creation" (p. 2729). According to Jordan (2010):

> A design has the ability to take me back to a place, time, or experience to which I would like to return; it can allow me to be part of a community and can help define me in relation to others in a group; and it can even help me signify who I want to become. (p. 11)

Identifying closely with an experience can create an affinity, which is tied into a sense of self:

> Affinities based on self-image...may be nostalgic (past tense) and relate to who we thought we were or a fondness we have for past experiences. It can also be definitive (present tense) and help us communicate who we are and to which community we belong. And affinity may even be aspirational (future tense) and allow us to project who we want to be and our ideals for our future. (Jordan, 2010, p. 8)

Self concepts and design. Understanding participants and their ideas of self is critical, because "information about interest and identity development could usefully inform the design of tasks, exhibits, and activities; instructional conversations; and expectations for learner participation and achievement" (Renninger, 2009, p. 105). Shared authorship, co-authorship and "design in partnership" can be explained as "designing 'with' as opposed to 'for' people," and includes "collaboration between designers and future users" (Damazio et al., 2009, p. 2729). This participatory and inclusive approach is important for museums because "museums should grow out of life experiences and be used to reflect back on life" (Hein, 2004, p. 420). In order to create personal meaning, "museum experiences, even active ones, still need to be associated with richer, authentic life experiences" (Hein, 2004, p. 423). This implies an important and relatively newly-acknowledged significance for design:

> "bridging the gap between growing expert knowledge and satisfying an increasing desire for democratic participation in its dissemination can be seen as an important cultural role for design" (Lake-Hammond & Waite, 2010, p. 88).

Designed experiences are inherently tied to the self, since "identity, like interest, develops through interactions... both interest and identity develop in relation to available experiences and to how learners perceive, understand, and represent these experiences".

(Renninger, 2009, p. 106)

Self concepts and other factors. Self concepts are related to the Affect factor group because affinity is comprised of an emotional response to beauty and identity, and "identity may be best explored in terms of the self image" (Jordan, 2010, p. 6). The amount of effort and self-investment in an experience can determine affective response, since "the effort exerted in the acquisition of an object is one of the aspects responsible for the feeling of independence that can be generated by the relationship of people with their objects" (Damazio et al., 2009, p. 2730).

usability

Usability can be described as the practice of designing for ease of use, a field rooted in "cognitive sciences—a combination of psychology, computer science, human factors, and engineering" (Norman, 2002, p. 38). Usability derives from userfriendly, but "no precise definition of usability exists" (Alonso-Ríos et al., 2010, p. 53); many researchers rely on international standards (ISO) definitions (Ibid, p. 54). This study includes the following individual factors in the usability factor group: usability, *perceived ease of use, perceived usability*, and *perceived usefulness*.

Usability and humans. User-centered design can be described as an approach that promotes "the creation of objects that, by virtue of their physical forms and location invite certain kinds of use and not others," including the notion of "affordances" or interactions where intended use is natural and apparent (Allen, 2004, p. S21). Alonso-Ríos et al. (2010) found six areas that pertain to usability: knowability, operability, efficiency, robustness, safety, and subjective satisfaction (p. 60).

Usability and design. According to Forlizzi and Ford (2000), "a successful design will take into consideration all the components in the user-product interaction: user, product, and context of use" (p. 423). It's not enough to simply acknowledge the importance of usability; a more concrete and systematic approach is necessary because "designers need to demystify how we design for user experience and how the products we design achieve specific user experience goals" (Forlizzi & Ford, 2000, p. 419). According to Norman (2002), "human-centered design practices are most essential for tasks or situations that are stressful" since people can tolerate less-user friendly interactions in pleasant situations (p. 40). Usability is critical to museum experiences because a decline in interest and involvement known as museum fatigue can set in after about 30 minutes (Allen, 2004, p. S20).

Usability and other factors. Usability is related to the Cognition, Affect, and Context factor groups. Apprehension and usability "reduce the ever-present cognitive load on visitors, freeing them to focus on those aspects of the environment that are rewarding to them and worthy of their attention" (Allen, 2004, p. S24). O'Brien and Toms suggest "aesthetic judgments are not based solely on users' first impressions; the perceived usability of a system is intertwined with its visual presentation" (O'Brien & Toms, 2010, p. 63). According to Zhang and Li (2005), "IT designers or IT acquirers should pay attention not only to usefulness (IT suitability for tasks or jobs), and ease of use (the longtime goal of the human computer interaction field), but also to affective quality (the degree to which emotional reactions are evoked)" (p. 108). Context is a hugely important factor to determine what "usability" means in a given situation, hence "usability depends on context of use" (Alonso-Ríos et al., 2010, p. 60).

"Designers need to demystify how we design for user experience and how the products we design achieve specific user experience goals".

(Forlizzi & Ford, 2000, p. 419)

definitions

Active learning. Learning in a self-guided and problem-solving context, as opposed to learning through passive "tutorial-like, prompted interaction" (Van Nimwegen, Van Oostendorp, Burgos, & Koper, 2006, p. 786). Research suggests it's possible that "the more difficult condition perhaps instigates a deeper level of cognitive processing which eventually results in more effective learning" (Ibid).

Active prolonged engagement. Defined by Allen (2004) as creating both "minds-on" and "hands-on" experiences, especially those that combine "access to phenomena with opportunities for deeper cognitive experiences" (p, S25).

Affect. A "neutral" term describing "the concepts of affect, emotion, feelings, mood, motivation, and qualia" (Norman, 2002, p. 38). The "affective system is judgmental, assigning positive and negative valence to the environment rapidly and efficiently"; affect and cognition work together to help humans process information (Ibid).

Cognition. Defined by Norman (2002) as a neurological response that "interprets and makes sense of the world"; affect and cognition work together to help humans process information (p. 38).

Cognitive experience. The stream of incoming information perceived by humans during consciousness, according to Richard Carlson's (1997b) theory of experienced cognition. Also defined as interactions which "require us to think about what we are doing [and] require attention, cognitive effort, or problem-solving skills [sic]" (Forlizzi & Ford, 2000, p. 421).

Communication design. A holistic design approach which recognizes that designed information inherently exists inside of an experience; designers don't create artifacts but rather events (Frascara, 2004, p. 13).

Contemporary learning theories. Theories modeled on "contemporary research in the learning sciences [emphasizing] the importance of active learning, collaborative learning, and constructionist learning" (Birchfield et al., 2008, p. 965).

Context. For the purposes of the study, defined as influences surrounding and shaping experiences; Forlizzi and Ford (2000) note "user-product interactions take place in a context of use, shaped by social, cultural, and organizational behavior patterns" (p. 420).

Engagement. Can be described as prolonged interaction created by elements of "Focused Attention, Perceived Usability, Aesthetics, Endurability, Novelty, and Felt Involvement" (O'Brien & Toms, 2010, p. 62). Can include a flow state, which can be defined as being "fully involved with mind and body in an intrinsically motivated activity" (Allen, 2004, p. S23).

Experience. "A stream of valuable and not so valuable moments with a definite beginning…and ending" (Hassenzahl & Ullrich, 2007, p. 429). Defined by Dewey(1938) as "a transaction taking place between an individual and what, at the time, constitutes his environment" (p. 43); the environment is "whatever conditions interaction with personal needs, desires, purposes and capacities to create the experience" (p. 44).

Experience design. Creating interactive situations for humans (Forlizzi & Ford, 2000, p. 420); a broad term for design concerned with the "holistic user experience," with aspects that include information architecture, usability engineering, visual design, and interaction design (Morville & Rosenfeld, 2006, p. 10).

Experiential learning theory. An educational model based on the idea that humans create meaning from experience. Kolb created a formal Experiential Learning Theory (ELT) in 1984 based on the work of John Dewey, Kurt Lewin, and Jean Piaget (Kolb et al., 2001, p. 228).

Educational psychology. Applying psychological understanding to improve educational experiences; Entwistle et al. (2001) note that "educational research from a psychological perspective is generally directed towards a deeper understanding of teaching and learning processes in everyday contexts, with the ultimate intention of improving the quality and effectiveness of education" (pp. 103-104).

Human-centered design. "A multidisciplinary activity, which incorporates human factors and ergonomics knowledge and techniques with the objective of enhancing effectiveness and efficiency, improving human working conditions, and counteracting possible adverse effects of use on human health, safety and performance" ("UsabilityNet: Methods: ISO 13407," n.d.).

Human factors. The broad field of study concerning the cognitive, social and physical aspects of human systems and services, including ergonomics ("Human Factors and Ergonomics Society: Educational resources," n.d.).

Informal learning. Short-term, voluntary learning

definitions (continued)

which occurs outside of a formal curriculum; it can be self-directed, incidental, or socialized (Schugurensky, 2000).

Information architecture. "The structure and design of shared information environments," such as information products and experiences, that support the human-centered attributes of usability and findability (Morville & Rosenfeld, 2006, p. 4).

Interaction design. Creating interfaces for the "behavior of tasks and processes" humans encounter in an information system (Morville & Rosenfeld, 2006, p. 10).

Interactive environment. For the purposes of the study, defined as an environment that accepts and responds to input from humans ("Interactivity - Wikipedia, the free encyclopedia," n.d.).

Interactivity. "A feedback loop of action-reaction-interaction [which] involves collaboration or exchange" (Polaine, 2005, p. 151).

Narrative. In terms of exhibition design, a structure which "allows the audience to make sense of the objects on display, in relation to one another and their surrounding contexts" (Lake-Hammond & Waite, 2010, p. 91).

Shareability. A "design principle that refers to how a system, inter-face, or device engages a group of collocated, co-present users in shared inter-actions around the same content (or the same object) [sic]" (Hornecker, Marshall, & Rogers, 2007, p. 328).

Self concepts. For the purposes of the study, defined as influences on experience concerned with identity and self; designed experiences are inherently tied to the self, since "identity, like interest, develops through interactions…both interest and identity develop in relation to available experiences and to how learners perceive, understand, and represent these experiences" (Renninger, 2009, p. 106).

Social actor. "An organizational entity whose interactions are simultaneously enabled and constrained by the socio-technical affiliations and environments of the firm, its members, and its industry" (Lamb & Kling, 2003, p. 218).

Usability design. The practice of designing for ease of use, a field rooted in "cognitive sciences—a combination of psychology, computer science, human factors, and engineering" (Norman, 2002, p. 38). Usability derives from userfriendly, but "no precise definition of usability exists" (Alonso-Ríos, Vázquez-García, Mosqueira-Rey, & Moret-Bonillo, 2010, p. 53); many researchers rely on international standards (ISO) definitions (Ibid, p. 54).

User-centered design. An approach that promotes "the creation of objects that, by virtue of their physical forms and location invite certain kinds of use and not others," including the notion of "affordances" or interactions where intended use is natural and apparent (Allen, 2004, p. S21).

White paper. An "authoritative" and "informative" publication which "argue[s] a specific position or propose[s] a solution to a problem" and often addresses an audience outside the originating organization (Sakamuro & Stolley, 2010).

subject overview

Human interactions with information. Human consciousness can be defined as "an organizing principle of information processing by individuals acting in environments" (Carlson, 1997a, p. 126). The great influx of information with which humans interact on a daily basis requires human-centered approaches to information experiences (Wurman, Leifer, Sume, & Whitehouse, 2001). In order to engage with information in a meaningful way, formal and informal learning experiences must be designed using experiential, human-centered approaches (Dewey, 1938). This approach is examined in an area of inquiry known as experience design, which can be described as creating interactive situations for humans (Forlizzi & Ford, 2000, p. 420), and is also a broad term for design concerned with the "holistic user experience" with aspects that include information architecture, usability engineering, visual design, and interaction design (Morville & Rosenfeld, 2006, p. 10). Experience design exists as part of human-centered design, which can be defined as recognizing human needs in order to "[enhance] effectiveness and efficiency" ("UsabilityNet: Methods: ISO 13407," n.d.) of an information experience. An important aspect of human-centered experience design is usability design, which can be defined as the practice of designing for ease of use, a field rooted in "cognitive sciences—a combination of psychology, computer science, human factors, and engineering" (Norman, 2002, p. 38).

Ideal learning experiences are a "spiral" of cognitive responses including "experiencing, reflecting, thinking, and acting".

(Kolb, Boyatzis, & Mainemelis, 2001, p. 240)

Human interactions with information are viewed as both cognitive and emotional experiences; for example, learning and recall are affected by emotions that are present when cognition occurs (Carlson, 1997a, p. 123), and "the arousal accompanying emotion has an informational aspect, constituting part of the information manifold in which experienced cognition occurs" (Carlson, 1997a, p. 113). Kolb et al. define ideal learning experiences as a "spiral" of cognitive responses including "experiencing, reflecting, thinking, and acting" (Kolb, Boyatzis, & Mainemelis, 2001, p. 240). Forlizzi and Ford (2000) define cognitive experiences as interactions which "require us to think about what we are doing…[and] require attention, cognitive effort, or problem-solving skills [sic]" (p. 421).

"There is an intimate and necessary relation between the processes of actual experience and education". (Dewey, 1938, p. 20)

Dewey (1938) proposed that "all human experience is ultimately social...it involves contact and communication" (p. 38). Human interactions with information are also social experiences; for example, humans consistently apply social rules (politeness, perceptions of gender) when interacting with computers (Lamb & Kling, 2003; Nass, Steuer, & Tauber, 1994). Lamb and Kling (2003) note that humans make choices about information communication technologies based on social aspects of their environment. Information experiences, like product experiences, exist in "a context of use, shaped by social, cultural and organizational behavior patterns" (Forlizzi & Ford, 2000, p. 420).

Experiential and informal learning. Experiential learning theory is an educational model based on the idea that humans create meaning from experience. Dewey's (1938) foundational work in this area suggests "there is an intimate and necessary relation between the processes of actual experience and education" (p. 20). Kolb created a formal Experiential Learning Theory (ELT) in 1984 based on the work of John Dewey, Kurt Lewin, and Jean Piaget (Kolb et al., 2001, p. 228). Both cognition and affect (emotion) influence ways humans process information (Norman, 2002, p. 38) and cognitive styles influence learning experiences (Kolb et al., 2001), including informal learning experiences. Informal learning can be defined as short-term, voluntary learning which occurs outside of a formal curriculum (such as classes, self-directed research, museums and galleries, etc.); this type of learning can be self-directed, incidental, or socialized (Schugurensky, 2000).

Interactive learning environments. Researchers exploring contemporary learning in museums suggest that informal learning is enhanced when humans partic-

subject overview (continued)

ipate in interactive experiences (Allen, 2004; Birchfield, Mechtley, Hatton, & Thornburg, 2008). Birchfield et al. (2008) note, "contemporary research in the learning sciences emphasizes the importance of active learning, collaborative learning, and constructionist learning" (2008, p. 965). Allen (2004) defines active prolonged engagement as creating both "minds-on" and "hands-on" experiences, especially those that combine "access to phenomena with opportunities for deeper cognitive experiences" (p. S25). Allen's (2004) work suggests "exhibits may have an optimal degree of interactivity, and that formative evaluation is essential for ensuring that the interactive features work together harmoniously" (Ibid).

Informal and experiential learning, in an interactive environment such as a museum, has the potential to be mutually beneficial for both the participant (the learner) and the experience provider (the museum); for example, participants often develop an affinity for or emotional engagement with the provider of a positive experience (Damazio, Dal Bianco, Lima, & Menezes, 2009). Van Moer et al. (2008) note, "information-based exhibits often create reactions without personal engagement and develop experiences not meaningful enough to capture visitors' attention and open up to further growth" (p. 44). Continued exploration results when human impulses and desires are recognized as motivating factors in an educational experience (Dewey, 1938).

Informal learning is enhanced when humans participate in interactive experiences.

(Allen, 2004; Birchfield et al. 2008)

research methods

RESEARCH PARAMETERS

The framing of this topic requires development of an intersection between the fields of human-center design (which encompasses information design (Morville & Rosenfeld, 2006; Wurman et al., 2001), human-computer interaction (Lamb & Kling, 2003; Nass et al., 1994), design psychology (Norman, 2004) and educational psychology (Dewey, 1938; Kolb et al., 2001), and museum studies (Hein, 2004; Hennes, 2002). The study is designed as a literature review, which enables the researcher to link pertinent information from these areas into a cohesive body of knowledge in order to "build bridges to related topic areas" (Cooper, 1998, p. 3).

RESEARCH QUESTIONS

Primary research question. According to selected literature, what cognitive and emotional factors should museum educators, exhibit designers, information designers, and interaction designers consider when designing informal learning experiences in interactive learning environments?

Secondary research questions.

- How do participants interact with information in a self-directed interactive environment like a museum setting?
- What outcomes define a positive informal learning experience in a self-directed interactive environment like a museum setting?
- How do selected current theories describe cognitive responses during informal learning experiences, especially in interactive environments?
- How do selected current theories describe emotional responses during informal learning experiences, especially in interactive environments?

RESEARCH DELIMITATIONS

Topic. The study identifies cognitive and emotional factors influencing informal learning experiences in interactive environments, as present in current scholarly literature, in order to provide an overview of an interdisciplinary topic. The intent is to synthesize current research (Cooper, 1998, p. 2) from four distinct areas (educational and design psychology, information design, human-computer interaction, and museum studies) and present it in a form applicable to both scholars and design practitioners in these areas. Individually, these subject areas explain aspects of a user's learning experience, but collectively current research provides a more complex and interdisciplinary overview of that experience.

The study centers on experience design and experiential learning theory, operating on the assumption that individualized, human-centered design will provide optimal outcomes for participants engaging in informal learning experiences. Experiential learning theory recognizes that the individual is an integral part of learning "situations" comprised of interactions and continuity (Dewey, 1938) and places a particular emphasis on individual needs and interactions (Kolb et al., 2001). Although there are numerous historical design theories and approaches that may provide positive human outcomes, this researcher believes a contemporary, human-aware design approach should recognize ways differing design theories serve the user, and apply sophisticated solutions balancing human needs with other concerns.

Focus. Focus of the study is on cognitive (Carlson, 1997b) and emotional (Damazio et al., 2009) factors which influence informal learning in interactive information environments, such as museums (Hennes, 2002) and not ergonomic or physical accessibility factors. Human factors research includes many human-related concerns in the designed world ("Human Factors and Ergonomics Society: Educational resources," n.d.), but this study focuses on information and learning psychology rather than physical engineering aspects of interactive learning environments. Although cognitive and emotional factors may influence physical design, this study identifies influential factors rather than suggesting physical applications. The study focuses on adult factors rather than those specific to children, early education, or higher education. In order to extract factors, references addressing concepts and theories are preferred to those describing product studies or licensed approaches.

Type of sources. Literature is limited to scholarly (including peer reviewed) literature addressing the cognitive and emotional aspects of information design practices applicable to informal, interactive learning environments. Peer-reviewed journal articles and references whose content addresses multiple keywords are preferred, and peer-reviewed association publications like ACM's *interactions* magazine (Jordan, 2010) are also included. Recent non-academic publications by respected scholars, such as Donald Norman's *Emotional Design* (2004), are included, along with respected publishers such as O'Reilly (Morville & Rosenfeld, 2006)

research methods (continued)

and Rosenfeld (Young, 2008), to provide definitions and context.

Type of research design. The research study is approached from a constructivist philosophical worldview (Creswell, 2009, p. 8). The researcher has a communication design and fine art background, so a qualitative research design is desirable and literature employing qualitative strategies of inquiry, including those describing experiences (phenomenology) and explaining or seeking to understand (ethnography) are emphasized in the study (Creswell, 2009, p. 13). The study is designed as research synthesis (Cooper, 1998, p. 3) and presented as an integrative literature review (Ibid, p. 2).

DATA ANALYSIS PLAN OVERVIEW

Data collection process. Creswell (2009) identifies qualitative research as an iterative process of reflection, questioning, and writing; he notes, "qualitative data analysis is conducted concurrently with gathering data, making interpretations, and writing reports" (p. 184). An initial group of references addressing the research question and sub-questions are collected, but the analysis and interpretation portion of the research process informs these questions and they evolve during the research process, leading to further data collection.

Data coding and analysis procedure. High-quality, relevant references are coded by topic using content analysis procedures (Busha & Harter, 1980). The goal is to "quantify and analyze the presence, meanings and relationships of…words and concepts [within a text], then make inferences about the messages within the texts, the writer(s), the audience, and even the culture and time of which these are a part" (Busch et al., 2005).

SIGNIFICANCE

Academic significance. According to Creswell (2009), literature reviews are inherently significant if they "add to the pool of research knowledge" (p. 24). This study contributes knowledge by synthesizing current research from multiple disciplines (educational and design psychology, information design, human-computer interaction, and museum studies) and identifying overlaps.

Practical significance. Human interactions with information are growing and becoming more complex (Wurman et al., 2001). Information should be designed from a human-centered perspective (Norman, 2002, p. 40) in order to provide learning experiences that encourage ongoing exploration (Hein, 2004). Studies show human creativity and learning is enhanced during positive emotional states (Norman, 2004, p. 19). Although the amount of research in the area of design and emotion has increased in the last decade, design theory and practice have not fully capitalized on the advances from the last 25 years regarding the biology and neurology of emotion (Love, 2009). In order to create these experiences, designers must have access to the findings of current scholarly research in a form that allows them to apply current knowledge to their practice (Kolko, 2010, p. 80). By identifying influential cognitive and emotional factors emergent in current research, this study brings academic knowledge to practitioners in order to encourage the creation of human-centered learning experiences with information.

See ***Learning by Design: Cognitive and Emotional Factors Influencing Informal Learning Experiences in Interactive Environments*** (Leaper, 2011) for complete research parameters, search results, data analysis, annotated bibliography, and review of literature associated with this white paper.

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